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New moss records for Vanua Levu, Fiji

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Abstract

Fourteen species of mosses are newly recorded from the Savusa area and the greater Delaikoro area on Vanua Levu, Fiji's second largest island. The fourteen species belong to ten different families, Cyrtopodaceae, Dicranaceae, Hypnodendraceae, Meteoriaceae, Neckeraceae, Orthotrichaceae, Polytrichaceae, Pterobryaceae, Ptychomniaceae and Sematophyllaceae. Four moss species are new records for Vanua Levu, *Pogonatum graeffeanum* (Müll.Hal.) A.Jaeger, *Macromitrium angulatum* Mitt., *Meiothecium hamatum* Broth. and *Papillaria helictophylla* (Mont.) Broth., while the remaining ten species were previously reported from other locations. The novel distribution records for these species are provided, with notes on their extended range of distribution. Field illustrations of all fourteen taxa are provided, with voucher specimens deposited as permanent records at the South Pacific Regional Herbarium in Fiji.

Introduction

The history of moss collection in Fiji has consisted of several enumerations since the late 18th to mid-19th century (von Konrat *et al.* 2011). Most publications from the mid-1900s were reviews of collections undertaken by early expeditions in the 18th century, under the United States Exploring Expedition and the H.M.S. Herald expedition. One of the earliest known studies was by Sullivant (1854, 1859) who reviewed the collections made by Rich and Wilkes from 1838–1842. Müller (1857) reviewed the collections made by Thwaites in 1854, and these were reviewed again by Dixon and Greenwood (1930), who also included collections made by Mitten in 1861 and 1871. Whittier (1975) provides a thorough account of bryophyte collections in the 18th and 19th century and also reviewed collections by later naturalists leading up to the mid-1900s, including Bartram's work (Bartram 1936, 1944, 1950, 1956). According to Müller (2012), Miller *et al.* (1978) published the last comprehensive inventory of mosses in Fiji. In the most recent works by von Konrat *et al.* (2011), Fife and Naikatini (2011), the authors concluded that the moss flora for Fiji remains understudied and poorly documented across most of the islands. Müller (2012) provides a through literature overview of key moss references from the mid-1970s to the present, including works by Dixon and Greenwood (1930), Schultze-Motel (1973), Whittier (1975), Miller *et al.* (1978), Lin (1984), Reese and Mohamed (1985), Reese *et al.* (1986), Norris and Koronen (1987), Watanabe (1987), Enroth (1992), Higushi and Iwatsuki (1993), Iwatsuki and Suzuki (1996), Kruijer (2002), and Fife and Naikatini (2011). Müller's work on Taveuni, Fiji's third largest island, has provided the most recent additions to the moss flora for Fiji (Müller, 2012).

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A moss checklist and distribution records has yet to be produced specifically for Vanua Levu. Vanua Levu is the second largest island in Fiji, located north-east of Viti Levu (see map). Some of the known collections on the island were undertaken by Greenwood in 1917–1927, Peterson in 1924, Degener in 1940, and Whittier in 1975. With the handful of collections and inventories, there is considerable reliance on published literature by specialists having undertaken research on the Fijian flora to provide the most relevant and updated information, particularly with the local distributions. In Bartram's (1944, 1956) accounts of Fijian mosses, 288 species were listed with annotated collection sites. Whittier (1975) documented 305 moss species in the flora and provided some collection localities on Vanua Levu that included the coast of Macuata, Natewa Peninsula, parts of Labasa and Yanawai River. Other than the collections described herein, even the most recent moss collections have only been site specific: Fife in 2006–2008 on the islands of Viti Levu and Taveuni and Müller in 2012 on Taveuni. Hence, more groundwork remains to be undertaken.

In the present collection, 14 mosses are newly reported from the areas of Savusa and the greater Delaikoro area on the island of Vanua Levu. Four moss species are new records for Vanua Levu: *Pogonatum graeffeanum* (Müll. Hal.) A.Jaeger, *Macromitrium angulatum* Mitt., *Meiothecium hamatum* Broth. and *Papillaria helictophylla* (Mont.) Broth. The remaining ten species have previously been reported from Vanua Levu but with locations that lie beyond the peripherals of Savusa and Delaikoro sites. Nonetheless, the overall new island records show a significant range extension of the currently known distributions of the respective species, both within and outside the Fijian archipelago. Distribution records from earlier collection are also stated. Field photographs were taken by the author and are provided to aid identification and also because the moss flora is often not frequently illustrated in the published literature. All 14 voucher collections have been deposited as permanent records at the South Pacific Regional Herbarium located in Suva, Fiji.

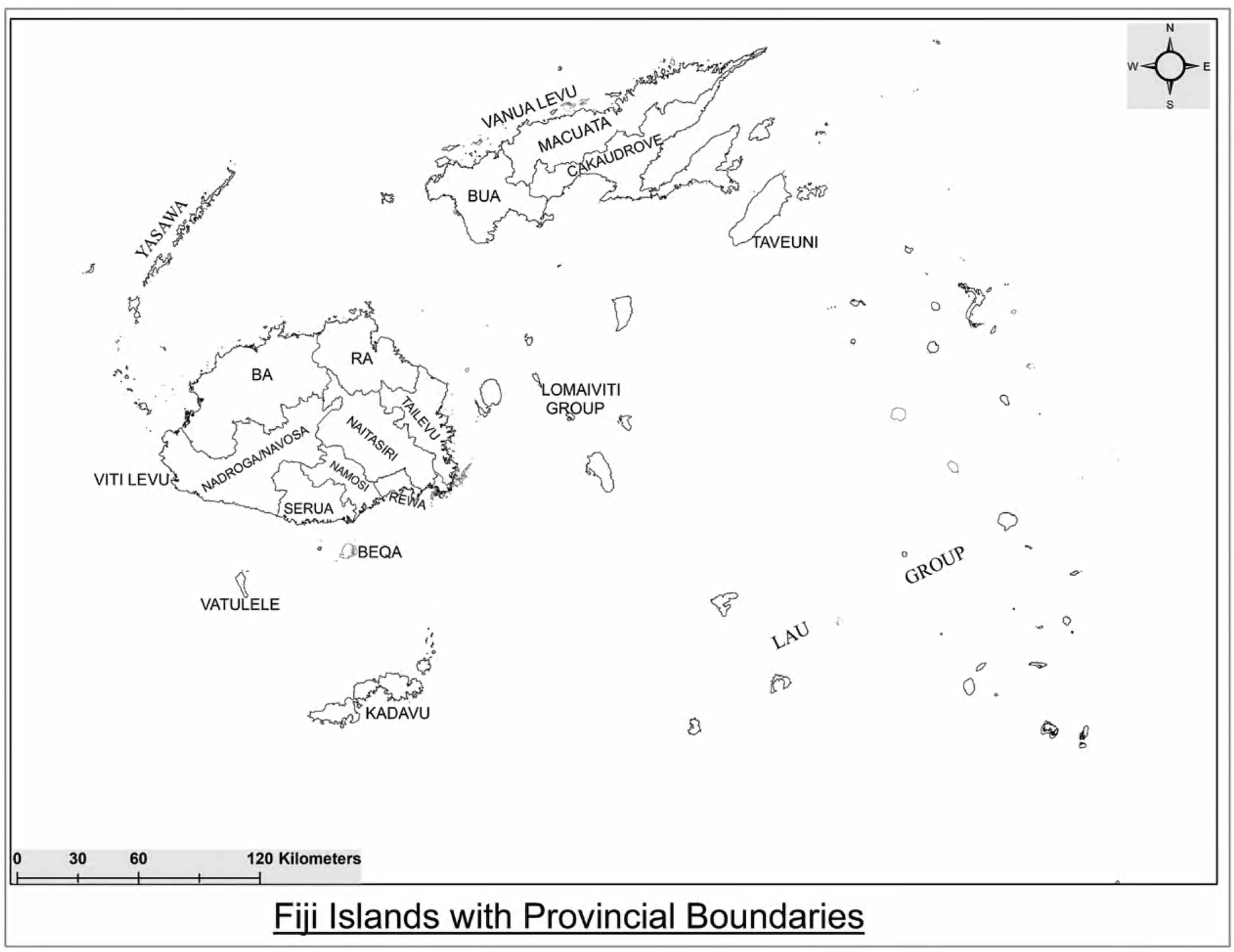

Fig. 1. Map of Fiji Islands with Provincial boundaries. Source: Conservation International (Fiji Program), 2022.

List of new moss records for Vanua Levu

Abbreviations: lat. - Latitude; long. – Longitude; CHR - Landcare Research New Zealand, Allan Herbarium, Lincoln, New Zealand; CNABH - Consortium of North American Bryophyte Herbaria; GBIF - Global Biodiversity Information Facility; SPRH – South Pacific Regional Herbarium, University of the South Pacific, Laucala Campus, Suva, Fiji.

1. *Pogonatum graeffeanum* (Müll.Hal.) A.Jaeger [Polytrichaceae]

Fiji, Vanua Levu, Cakaudrove Province: Vicinity of Savusa, on the slope embarkment with a dominant spread on the soil surface, 400 m a.s.l. 16.6353°S, 179.3710°E, *S.H.Tuiwawa 5508/2013*, Herbarium No.: *SPRH 37465*. (Fig. 2)

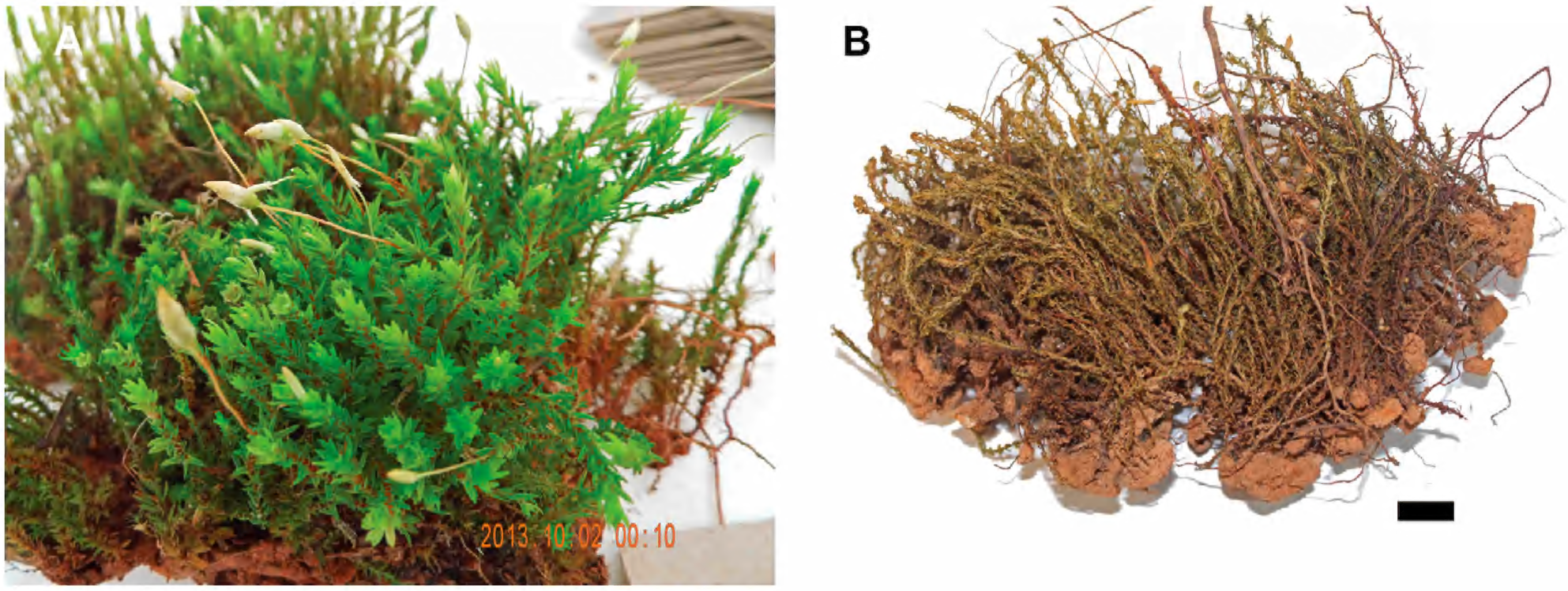

Fig. 2. Fertile specimen of *Pogonatum graeffeanum* sampled off the soil substrate of its natural habitat. A. Live plant. B. Dried specmen (*S.H.Tuiwawa 5508/2013*). Scale bar = 1 cm.

Specimen Examined: Fiji, Viti Levu, Province of Namosi. On the road in the vicinity of Namosi village, soil embarkment of stream bank, 380 m a.s.l. 24 April 2007, *A.J.Fife 12321-CHR 595145 [SPRH 28518]*. Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: the greater Delaikoro area (new record).

Notes: The specimen is the first known recorded sample of *Pogonatum graeffeanum* from Vanua Levu. Previous collections include those by Fife in 2007 on Viti Levu and annotations by Whittier in 1975 in parts of Viti Levu (Gibbs 1909; Dixon and Greenwood 1930; Greenwood 1946; Bartram 1956); and Ovalau (Müller 1874; Dixon and Greenwood 1930). Bartram in 1936 recorded a specimen from the island of Koro. GBIF has occurrence records of *P. graeffeanum* in the eastern parts of the South Pacific.

2. *Meiothecium hamatum* Broth. [Sematophyllaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Upper slopes of Delaikoro. On tree bark. 940 m a.s.l. 16.3514°S, 179.1851°E, *S.H.Tuiwawa 5516/2013*, Herbarium No.: *SPRH 37473*. (Fig. 3)

Specimen examined: Fiji, Viti Levu, Ba province. Central highlands, Monasavu dam depot site, Fiji map series 31, map sheet N27, Epiphytic on tree, c. 800 m a.s.l., 16 April 2007, *A.J.Fife 12631-CHR 587970 [SPRH 28499]*. Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: vicinity of Delaikoro (new record).

Notes: This is the first record of *Meiothecium hamatum* from Vanua Levu. With reference to recent publication by Müller (2012), there is no mention of this species occurring on Taveuni nor Vanua Levu in the previous works by Dixon and Greenwood (1930), Schultze-Motel (1973) or Miller *et al.* (1978). GBIF records occurrences of *M. hamatum* in parts of Asia, New Caledonia, and parts of Polynesia.

Fig. 3. Fertile sample of *Meiothecium hamatum* (*S.H.Tuiwawa 5516/2013*). Scale bar = 1 cm.

3. *Spiridens aristifolius* Mitt. [Hypnodendraceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Upper slopes of Delaikoro, on tree trunk, 890 m a.s.l., 16.3514°S, 179.1851°E, *S.H.Tuiwawa 5520/2013*, Herbarium No.: *SPRH 37477*. (Fig. 4)

Fig. 4. Live specimen of *Spiridens aristifolius* (*S.H.Tuiwawa 5520/2013*). Scale bar = 1 cm.

Specimen examined: Viti Levu, Namosi province. Track to Mt. Voma, on trunk of a tree fern, 700 m a.s.l. 25 April 2007, *A.J.Fife 12388-CHR 595212 [SPRH 28446]*. Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: vicinity of Delaikoro (new locality record).

Notes: Fife describes this species as having been common in abundance within the vicinity of Mt. Voma on Viti Levu. Bartram in 1936 annotates a specimen from Taveuni and a different locality site on Vanua Levu. The new occurrence is a range extension from the known site on Viti Levu. GBIF reports the occurrences of the species in Indonesia and throughout the western and eastern parts of the South Pacific.

4. *Papillaria helictophylla* (Mont.) Broth. [Meteoriaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Upper slopes of Savusa, on bark of tree, 850 m a.s.l., 16.6353°S, 179.3709°E, *S.H.Tuiwawa 5521/2013*, Herbarium No.: *SPRH 37477*. (Fig. 5)

Fig. 5. Specimen of *Papillaria helictophylla* (*S.H.Tuiwawa 5521/2013*). Scale bar = 1 cm.

Specimen Examined: Fiji, Kadavu: vicinity of the upper slopes of Mt. Washington, on shaded bark of tree, 500–800 m a.s.l., 17 July 1974, *D.H.Norris 45514 [SPRH 29124]*. Determined by D.H.Norris.

Distribution in Fiji: Vanua Levu, Savusa area (new record).

Notes: This is the first record of *Papillaria helictophylla* on Vanua Levu. The species was first collected on Kadavu in 1974 by D.H.Norris. With reference to recent publication by Müller (2012) on Taveuni, there is no mention of this species occurring on Taveuni nor Vanua Levu in the previous works by Dixon and Greenwood (1930), Schultze-Motel (1973), and Miller *et al.* (1978). GBIF records the extended range of distribution of the species throughout the South Pacific.

5. *Macromitrium angulatum* Mitt. [Orthotrichaceae]

Fiji, Vanua Levu, Cakaudrove Province: On the track to Delaikoro, epiphytic on exposed tree branch, 800 m a.s.l. 16.5868° S, 179.3145°E, *S.H.Tuiwawa 5111/2013*, Herbarium No.: *SPRH 37468.* (Fig. 6)

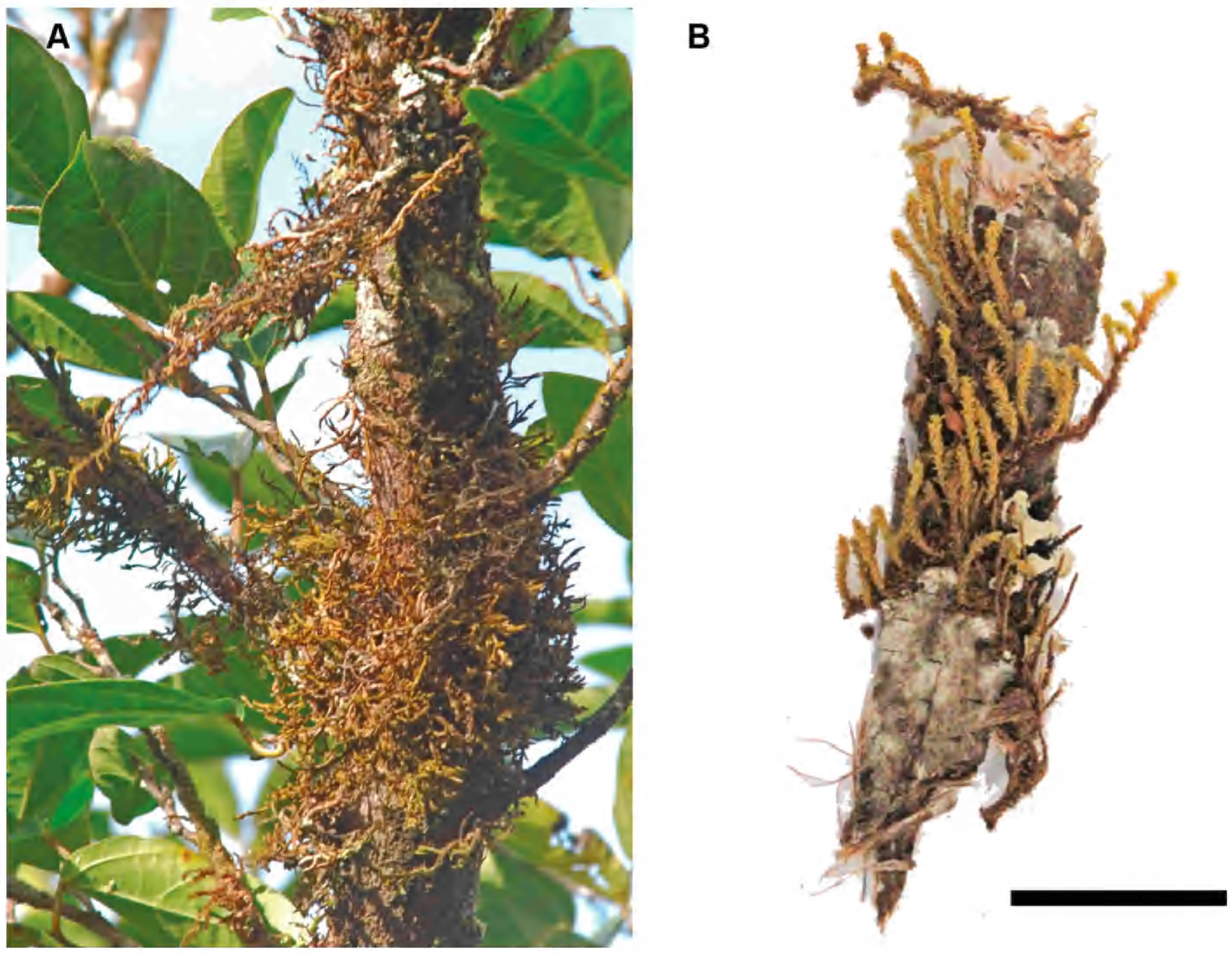

Fig. 6. Epiphytic *Macromitrium angulatum*. A. in its natural habitat. B. Sample of the fertile specimen (*S.H.Tuiwawa 5111/2013*). Scale bar = 1 cm.

Specimen examined: Fiji, Viti Levu, Ba province: dense rainforest at top of Mt. Lomalagi, east of Nadarivatu, on tree, 1100 m a.s.l., 28 June 1974, *D.H.Norris 44536 [SPRH 28860].* Determined by D.H.Norris.

Distribution in Fiji: Vanua Levu: vicinity of Delaikoro (new record). **Kadavu**: upper slopes of Mt. Washington, *D.H.Norris 45544 [SPRH 28861].*

Notes: Whittier in 1975 annotated a specimen on Viti Levu at a different location. GBIF has recorded occurrences of this species in Papua New Guinea and New Zealand.

6. *Floribundaria aeruginosa* (Dozy & Molk.) M.Fleisch. [Meteoriaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Off the road track to Delaikoro, at the bottom of tree trunk, 800 m a.s.l., 16.5868°S, 179.3145°E, *S.H.Tuiwawa 5514/2013*, Herbarium No.: *SPRH 37471*. (Fig. 7)

Fig. 7. Sample of *Floribundaria aeruginosa* (*S.H.Tuiwawa 5514/2013*). Scale bar = 1 cm.

Specimen examined: Fiji, Viti Levu, Ba province, vicinity of Mt. Koro-O, Fiji map series 31, sheet M27, mid-elevation mixed podocarp and kauri forest with steep clay slopes and several intermittent rivulets over basalt bedrock, 875 m a.s.l., 17 April 2008, *A.J.Fife 12705-CHR 618231 [SPRH 28618].* Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: vicinity of Delaikoro (new locality record). **Viti Levu:** vicinity of Namosi village, *A.J.Fife 12308-CHR 595132 [SPRH 28619]*; vicinity of Monasavu, *A.J.Fife 12592-CHR 618297 [SPRH 28620]*; track to Mt. Voma, *A.J.Fife 12376-CHR 595200 [SPRH 28621]*; lower slopes of Mt. Korobaba, *A.J.Fife 12265-CHR 595094 [SPRH 28617]*. **Taveuni**: lower track of Lake Tagimoucia, *A.J.Fife 12529-CHR 618237 [SPRH 28616].*

Notes: This is the first record of *Floribundaria aeruginosa* from the Delaikoro site on Vanua Levu. Whittier (1975) annotates several other localities on parts of Viti Levu (Dixon and Greenwood 1930; Greenwood, 1936); Vanua Levu (Bartram 1936) and Ovalau (citation without locality details of the collection, Müller 1874; Dixon and Greenwood 1930). GBIF records this species in the Congo and throughout Polynesia.

7. *Garovaglia elegans* (Dozy & Molk) Hampe ex Bosch & Sande Lac. [Ptychomniaceae]

Fiji, Vanua Levu, Cakaudrove Province: On the slope embarkments of Delaikoro. Epiphytic on tree branches. 850m a.s.l. 16.5867°S, 179.3144°E, *S.H.Tuiwawa 5509/2013*, Herbarium No.: *SPRH 37466*. (Fig. 8).

Specimen examined: Fiji: Viti Levu Island: western flank of Mt. Tomaniivi on track from Navai village, Fiji Map series 31, Sheet N27, on fallen branch, 1050 m a.s.l., 18 April 2008, *A.J.Fife 12725-CHR 618183 [SPRH 28623].* Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: greater Delaikoro area (new locality record); vicinity of Mt. Mariko. *D.H.Norris 45272 [SPRH 28932]*. **Taveuni:** vicinity of Mt. Des Voux, *A.J.Fife 12564-CHR 618269 [SPRH 28622].*

Notes: CNABH records the occurrence of *G. elegans* in parts of Asia.

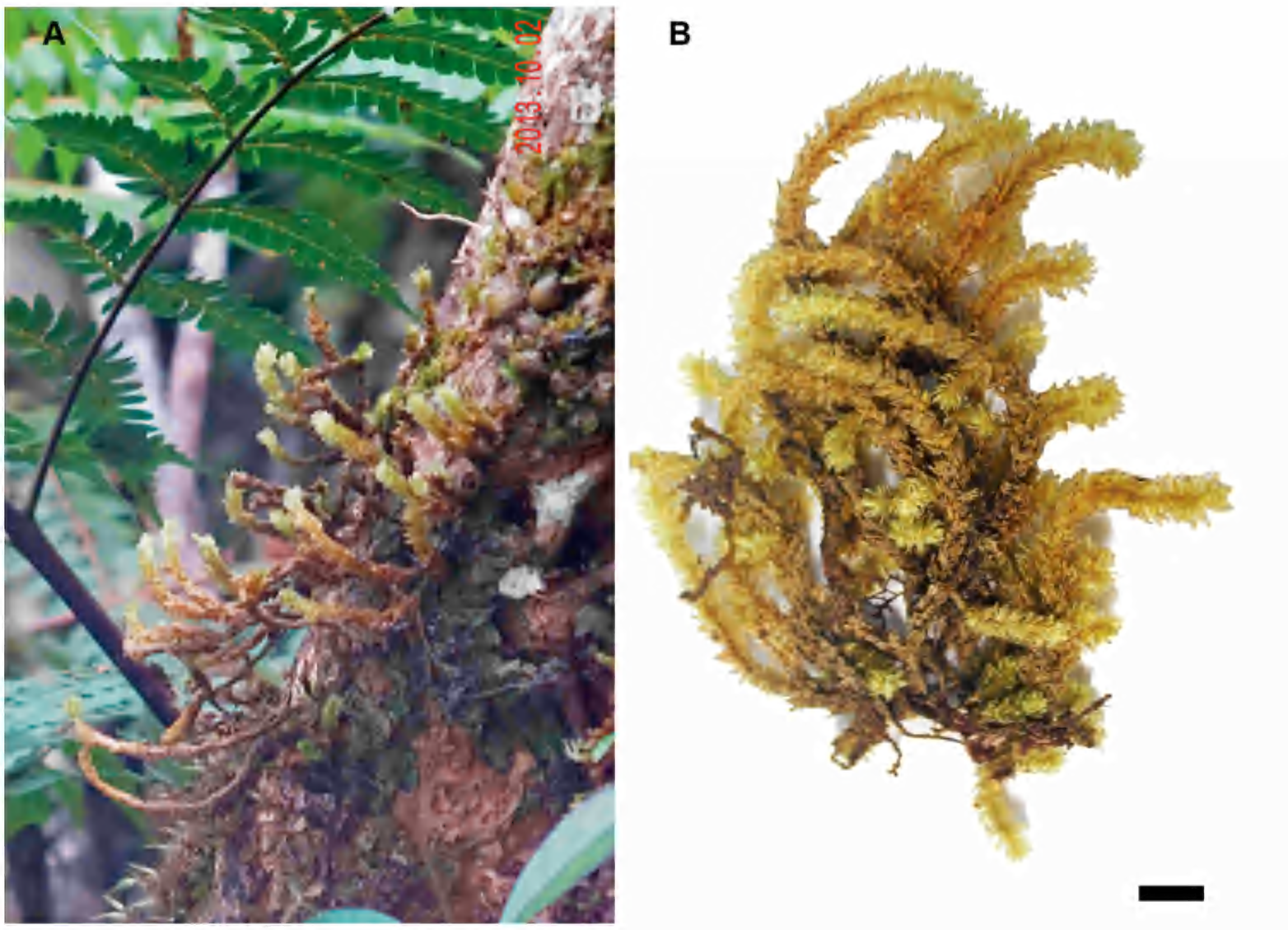

Fig. 8. Epiphytic *Garovaglia elegans*. A. On tree branches in natural habitat. B. Sample of the fertile specimen (*S.H.Tuiwawa 5509/2013*). Scale bar = 1 cm.

8. *Macromitrium incurvifolium* (Hook. & Grev.) Schwägr. [Orthotrichaceae]

Fiji, Vanua Levu, Cakaudrove Province: Along the gentle slopes of Delaikoro, epiphytic on tree branches, 900 m a.s.l., 16.5864°S, 179.3160°E, *S.H.Tuiwawa 5510/2013*, Herbarium No.: *SPRH 37467*. (Fig. 9)

Fig. 9. Epiphytic *Macromitrium incurvifolium*. A. Natural habitat on a tree branch. B. Sample of the fertile specimen (*S.H.Tuiwawa 5510/2013*). Scale bar = 1 cm.

Specimen examined: Fiji, Viti Levu, central highland Monasavu lake area, c. 6 km due south of the Monasavu dam on road that passes near Nadelaidovukula peak, Fiji map series 31, sheet N27, on *Freycinetia* leaves, 1230 m a.s.l. 15 April 2008, *A.J.Fife 12616-CHR 617435 [SPRH 28597]*. Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: vicinity of Delaikoro (new locality record); Mt. Mariko, *D.H.Norris 45259 [SPRH 28849]*. **Viti Levu**: vicinity of the Monasavu dam, *A.J.Fife 12545-CHR 618251 [SPRH 28493]*; slope of Mt. Tomaniivi, *D.H.Norris 44668 [SPRH 28856]*; Mt. Lomalagi, *D.H.Norris 44535 [SPRH 28855]*; Wainikatama stream in Namosi, *A.J.Fife 12344-CHR 595168 [SPRH 28495]*; vicinity of Nakavu village in Namosi, *A.J.Fife 12776-CHR 618306 [SPRH 28491]*. **Taveuni**: vicinity of lake Tagimoucia, *D.H.Norris 45098 [SPRH 28850]*; vicinity of Mt. Des Voux, *A.J.Fife 12545-CHR 618251 [SPRH 28493]*.

Notes: It's habit and morphology in the field closely resembles *Macromitrium angulatum*. Whittier (1975) records the occurrence of this species in other localities on Viti Levu (Gibbs 1909; Dixon and Greenwood 1930), Vanua Levu (Bartram 1936) and Taveuni (Bartram 1936). GBIF has reported occurrences of *M. incurvifolium* from South America, India, parts of Asia, Australia, and other Pacific Island countries.

9. *Bescherellia cryphaeoides* (Müll.Hal.) M.Fleisch. [Cyrtopodaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Off the road track to Delaikoro, epiphytic on tree branches, 850 m a.s.l., 16.5870°S, 179.3140°E, *S.H.Tuiwawa 5512/2013*, Herbarium No.: *SPRH 37469*. (Fig. 10)

Fig. 10. *Bescherellia cryphaeoides* on a sample tree bark (*S.H.Tuiwawa 5512/2013*). Scale bar = 1 cm.

Specimen examined: Fiji, Viti Levu, Namosi province. On dry vertical basalt in mid-elevation rainforest, 700 m a.s.l., 25 April 2007, *A.J.Fife 12383-CHR 525207 [SPRH 28674]*. Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: Mt. Delaikoro (new locality record).

Notes: This is the first record of *Bescherellia cryphaeoides* from the locality of the greater Delaikoro area in Vanua Levu. It was collected from a different location on Vanua Levu by Bartram in 1936. Whittier (1975) listed a collection in the island of Ovalau by Müller (1874) and Dixon and Greenwood (1930) however the locality is not specified. Fife in 2007 describe the species as rare in abundance in the vicinity of Mt. Voma on Viti Levu. Currently, neither GBIF nor CNABH has records of this species in any of its databases however TROPICOS lists one specimen from the Philippines.

10. *Leucoloma tenuifolium* Mitt. [Dicranaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Upper slopes of Savusa, on the bark of a tree, 310 m a.s.l., 16.6353°S, 179.3709°E, *S.H.Tuiwawa 5515/2013*, Herbarium No.: *SPRH 37472*. (Fig. 11)

Fig. 11. Samples of *Leucoloma tenuifolia* (*S.H.Tuiwawa 5515/2013*). Scale bar = 1 cm.

Specimen examined: Fiji: Viti Levu, Namosi province, Wainikatama Stream, near temporary mining camp, c. 5km SE (via road) of Namosi village on Namosi Road, 380 m a.s.l., 24 April 2007, *A.J. Fife 12332-CHR 595156 [SPRH 28598]*. Determined by Allan Fife.

Distribution in Fiji: Vanua Levu: Savusa area (new locality record); vicinity of Mt. Mariko, *D.H.Norris 45226 [SPRH 28875]*. **Viti Levu**: vicinity of Mt. Victoria, *D.H.Norris 44766 [SPRH 44766]*; vicinity of Nadarivatu, *D.H.Norris 44413 [SPRH 28863]*; summit of Mt. Korobaba, *D.H.Norris 44857 [SPRH 28870]*. **Taveuni**: vicinity of lake Tagimoucia, *D.H.Norris 45072 [SPRH 28890]*. **Kadavu**: upper slopes of Mt. Washington, *D.H.Norris 45495 [SPRH 28868]*.

Notes: Whittier (1975) reports further locality distribution on Viti Levu (Dixon and Greenwood 1930; Greenwood 1946; Bartram 1956), Vanua Levu (Bartram 1936) and Taveuni (Bartram 1936). GBIF reports *L. tenuifolia* in parts of Asia, parts of Polynesia and New Caledonia thus providing an overview of its range of distribution across the South Pacific.

11. *Leucobryum sanctum* Hampe [Dicranaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Along upper slopes of Delaikoro, on soil surface, 900 m a.s.l., 16.5868°S, 179.3145°E, *S.H.Tuiwawa 5517/2013*, Herbarium No.: *SPRH 37474*. (Fig. 12)

Fig. 12. Samples of *Leucobryum sanctum* (*S.H.Tuiwawa 5517/2013*). Scale bar = 1 cm.

Specimen examined: Fiji, Taveuni, Cakaudrove province: on moist, rather shaded soil along trail in dense rainforest at top of ridge on west side of Lake Tagimoucia, southeast of Somosomo, 600–900 m a.s.l., 6 July 1974, *D.H.Norris 45099 [SPRH 29062]*. Determined by D.H.Norris.

Distribution in Fiji: Vanua Levu: Delaikoro area (new locality record); vicinity of Mt. Mariko, *D.H.Norris 45251 [SPRH 29063]*. **Viti Levu**: upper pool vicinity of Colo-i-Suva, *A.J.Fife 12400-CHR 595224 [SPRH 28585];* vicinity of Nakavu forest Management site, *A.J. Fife 12757-CHR 618205 [SPRH 28586]*. **Taveuni:** vicinity of the lake Tagimoucia, *D.H.Norris 45099 [SPRH 29062]*.

Notes: GBIF has recorded occurrences of *L. sanctum* in the United States, India, parts of Asia, Australia, and parts of the South Pacific.

12. *Symphysodontella cylindracea* (Mont.) M.Fleisch. [Pterobryaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Upper slopes of Delaikoro, on tree bark, 840 m a.s.l., 16.5868°S, 179.3144°E, *S.H.Tuiwawa 5518/2013*, Herbarium No.: *SPRH 37475*. (Fig. 13)

Fig. 13. Specimen of *Symphysodontella cylindracea* (*S.H.Tuiwawa 5518/2013*). Scale bar = 1 cm.

Specimen Examined: Viti Levu, Ba province. In the lower dense rainforest slopes of Mt. Victoria, east of Nadarivatu, 800–1000 m a.s.l., 29 June 1974, *D.H.Norris 44788 [SPRH 29148]*. Determined by D.H.Norris.

Distribution in Fiji: Vanua Levu, vicinity of Mt. Delaikoro (new locality record); vicinity of Mt. Mariko, *D.H.Norris 45285 [SPRH 29026]*. **Taveuni**: disturbed forest in the vicinity of lake Tagimoucia, *D.H.Norris 44991 [SPRH 29027]*. **Viti Levu**: vicinity of Mt. Victoria, *D.H.Norris 44788 [SPRH 29148]*.

Notes: This is the first record of *Symphysodontella cylindracea* from Delaikoro in Vanua Levu. Bartram (1936) annotates a specimen at a different site location. CNABH have records of *S. cylindracea* occurring in Indonesia, Australia, New Zealand with a range extension across parts of the South Pacific.

13. *Thamnobryum ellipticum* (Bosch & Sande Lac.) Nieuwl. [Neckeraceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Slopes of Savusa, on lower tree trunk, 350 m a.s.l., 16.6334°S, 179.3654°E, *S.H.Tuiwawa 5519/2013*, Herbarium No.: *SPRH 37476*. (Fig. 14)

Specimen Examined: Fiji, Vanua Levu, Cakaudrove province. On moist, shaded bark of tree in dense rainforest on middle, eastern slopes of Mt. Mariko. 400–600m a.s.l., 9 July 1974, *D.H.Norris 45206 [SPRH 28940]*. Determined by D.H.Norris.

Distribution in Fiji: Vanua Levu, Savusa area (new locality record); vicinity of Mt. Mariko, *D.H.Norris 45152 [SPRH 28941]*. **Viti Levu**: vicinity of Colo-i-Suva, *D.H.Norris 44369 [SPRH 28939]*.

Notes: This is the first record of *Thamnobryum ellipticum* on Savusa. CNABH has record occurrences of the species from parts of Asia and Papua New Guinea.

Fig. 14. Live samples of *Thamnobryum ellipticum* (*S.H.Tuiwawa 5519/2013*). Scale bar = 1 cm.

14. *Leucobryum scalare* Müll.Hal. ex M.Fleisch. [Dicranaceae]

Fiji Islands, Vanua Levu, Cakaudrove Province: Middle slopes of Savusa area, on soil surface, 410 m a.s.l., 16.6334°S, 179.3654°E, *S.H.Tuiwawa 5520/2013*, Herbarium No.: *SPRH 37477*. (Fig. 15)

Fig. 15. Live samples of *Leucobryum scalare* (*S.H.Tuiwawa 5520/2013*). Scale bar = 1 cm.

Specimen Examined: Vanua Levu, Cakaudrove Province, eastern slopes of Mt. Mariko, on shaded bark of tree, 400–600 m a.s.l., 9 July 1974, *D.H.Norris 45241 [SPRH 28873]*. Determined by D.H.Norris.

Distribution in Fiji: Vanua Levu: vicinity of Savusa (new locality record); vicinity of Mt. Mariko, *D.H.Norris 45393 [SPRH 28879]*. **Viti Levu:** vicinity of Mt. Lomalagi, Nadarivatu, *D.H.Norris 44504 [SPRH 29066]*; summit of Mt. Victoria, *D.H.Norris 44596 [SPRH 29067]*. **Kadavu:** vicinity of Mt. Washington, *D.H.Norris 45506 [SPRH 28893]*.

Notes: GBIF records this species as having a global distribution with an extent that includes parts of the South Pacific – New Caledonia, French Polynesia, and American Samoa.

Acknowledgment

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Eriocaulon insectum, a new species of Eriocaulaceae from Cape York, Queensland

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Abstract

A new species of pipewort (*Eriocaulon*; Eriocaulaceae) from Cape York, Queensland was recently discovered. *Eriocaulon insectum* Baleeiro & R.W.Jobson is distinguished from all other species by its golden-brown inflorescence head, having female flowers with large, winged sepals with two black spots, four black, exerted stamens, with male sepals as a spathe, and seeds with 3–5 hyaline, T-shaped peg-like projections. Diagnostic characters are illustrated and tabulated with comparison to closely related species. A taxonomic key containing all known species from Cape York is provided, and habitat preference, distribution, and conservation status are discussed and compared to that of closely related species.

Introduction

Eriocaulon L. (Eriocaulaceae, Poales) consists of more than 400 species with a worldwide distribution occupying a wide range of aquatic habitats, mostly in tropical regions (Giulietti *et al.* 2012, Giulietti and Hensold 1990, Han *et al.* 2019, Larridon *et al.* 2019). Most of the 33 recognised Australian species are confined to the Monsoon Tropics, with a few extending to temperate regions (Davies *et al.* 2007, Leach 2000, 2017). The Monsoon Tropics contains Australia's highest species richness involving 21 biogeographic regions, with the greatest endemicity found across Kimberley, Arnhem Land, and Cape York (Crisp *et al.* 1995, Kalkman and Orr 2012, Jobson *et al.* 2017). Recent studies of ancient plant species exchange between the Sunda and Sahul shelves demonstrate that the relatively under-explored Cape York Peninsula (CYP) was a gateway for species migration into Australia (Joyce *et al.* 2020). Of the six species with distributions extending into Asia (*E. australe* R.Br., *E. cinereum* R.Br., *E. setaceum* L., *E. truncatum* Buch.-Ham. ex Mart., *E. zollingerianum* Körn, *E. willdenovianum* Moldenke), all are found in Cape York, with *E. zollingerianum* Körn. known only from the Weipa region.

Eriocaulon insectum Baleeiro & R.W.Jobson is recognised as a new species based on morphology (this paper) and preliminary molecular phylogenetic data (Baleeiro *et al.,* in prep.). At first glance, and due mainly to the shape and golden-brown colour of the inflorescence head, *Eriocaulon insectum* could be confused with *E. zollingerianum* or *E. hamiltonianum* Mart., the latter of which is restricted to south-east Asia and New Guinea (Ansari and Balakrishnan 2009, Prajaksood *et al.* 2012, Rashmi and Krishnakumar 2014, Leach 2018). Despite its superficial similarity to *E. hamiltonianum, E. insectum* differs in having a 2-locular ovary, two sepals and

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petals, and four stamens. The closest species morphologically are the Australian *E. carpentariae* G.J.Leach and *E. concretum* F.Muell. (both endemics) and here, we compare and contrast the essential morphological characters differentiating these species (Table 1, Leach 2000, 2017).

The geographic distributions and habitat preferences are discussed and a diagnostic key of the 22 CYP species is provided.

Methods

Field trips to Northern Australia were undertaken in June 2022. General morphological measurements were made with a stereoscope and light microscope and images were obtained via camera lucida. The seed surface was air-dried, mounted, and coated with 4–5 nm of gold-palladium (40–60%) and then observed using a Thermo Scientific Phenom Pure Desktop Scanning Electron Microscope (SEM); both processes were carried out at the Queensland Herbarium, Brisbane, Australia.

Taxonomy

Eriocaulon insectum Baleeiro & R.W.Jobson, *sp. nov*.

Type: AUSTRALIA: QUEENSLAND: Cook District: Orchid Swamp, Steve Irwin Wildlife Reserve, 22 June 2022, *P.C. Baleeiro 619 & R.W. Jobson* (holo: BRI; iso: NSW).

Diagnosis: *Eriocaulon insectum* is similar to *E. carpentariae* and *E. concretum* but differs in having leaves 6–7-nerved, green scapes to 330 mm tall, each bearing a golden-brown inflorescence head, receptacle cylindrical, involucral bracts rhombic, flower bracts concave, female flowers monomorphic, sepals glabrous, four large, black, exerted stamens, and seeds with 3–5 hyaline, T-shaped peg-like projections.

Annual *herb* to 330 mm tall. *Leaves* lanceolate, 30–60 long, 3–4 mm wide, 6–7 nerved. Peduncle 120–320 mm long, with five ribs. Sheath 30–40 mm long. *Flower heads* golden-brown, ovoid, c. 5 mm long, c. 3 mm wide. *Involucral bracts* straw yellow, rhombic, c. 2 mm long, c. 1.5 mm wide, apex rounded, glabrous, strongly reflexed at maturity. *Floral bracts* straw yellow, concave, broadly obovate to almost circular, 1.5–2 mm long, c. 1 mm wide, glabrous, apex rounded or obtuse. *Receptacle* cylindrical, densely pilose. *Male flowers* 1.2–2 mm long, sepals 2, fused but split on one side to form a spathe, hyaline or straw yellow, c. 1.5 mm long, obtuse, irregularly lobed, glabrous; *petals* hyaline, ovate or fimbriate, obtuse, c. 0.2 mm long; *stamens* 4; *anthers* black. *Female flowers* monomorphic, sepals 2, straw yellow, navicular, broad dorsal wing with dark spot, 1.5–2 mm long, 2–3 mm wide, crested, glabrous; *petals* 2, hyaline, equal, linear, c. 1 mm long, acute, glabrous. *Ovary* 2–locular. *Seeds* c. 0.5 mm long, c. 0.2 mm diam.; epidermal cells with even wall thickenings and 3–5 thin, hyaline, unidirectional, T-shaped peg-like projections on transverse walls. (Figs 1, 2a, b, e, f, 3)

Additional specimens examined (precise locality withheld for conservation purposes)**:** AUSTRALIA: QUEENSLAND: COOK DISTRICT: Peninsula Developmental Road, 5.3 km to Yarraden, 21 Jun 2022, *P.C. Baleeiro 606 and R.W. Jobson* (BRI, NSW); Steve Irwin Wildlife Reserve, 24 Jun 2022, *P.C. Baleeiro 631 and R.W. Jobson* (BRI, NSW); Bamaga, 25 Jun 2022, *P.C. Baleeiro 640 and R.W. Jobson* (BRI, NSW); Telegraph Track, 29 Jun 2022, *P.C. Baleeiro 670 and R.W. Jobson* (BRI, NSW); near Yarraden, 29 Jun 2022, *P.C. Baleeiro 681 and R.W. Jobson* (BRI, NSW); N of Dixie Road, on Peninsula Developmental Road, 29 Jun 2022, *P.C. Baleeiro 688 and R.W. Jobson* (BRI, NSW).

Etymology: The specific epithet is taken from the Latin *insectum*, a reference to the winged female flower with two antennae-like styles that resemble a flying insect.

Distribution, ecology, and phenology: Endemic to Cape York Peninsula, north Queensland, from Bamaga near the tip, south to Dixie Station, and west to near Weipa in the Steve Irwin Wildlife Reserve (Fig. 4). Commonly found growing with *Eriocaulon clarksonii*, *E. depressum*, *E. fistulosum*, and *E. concretum* at the margins of wetlands and lakes with *Melaleuca* spp., among sedges and grasses (Fig. 2e). Found in flower in June.

Conservation status: *Eriocaulon insectum* is relatively common at known collection localities, and the similarity of the golden-brown inflorescence head to those of local sedges makes it inconspicuous in the field (Fig. 2a, b). This feature is likely the reason it is under-collected across Cape York Peninsula. Given the frequency of occurrence across CYP, often in conservation reserves, we suggest *E. insectum* is not threatened and recommend the conservation status of Least Concern.

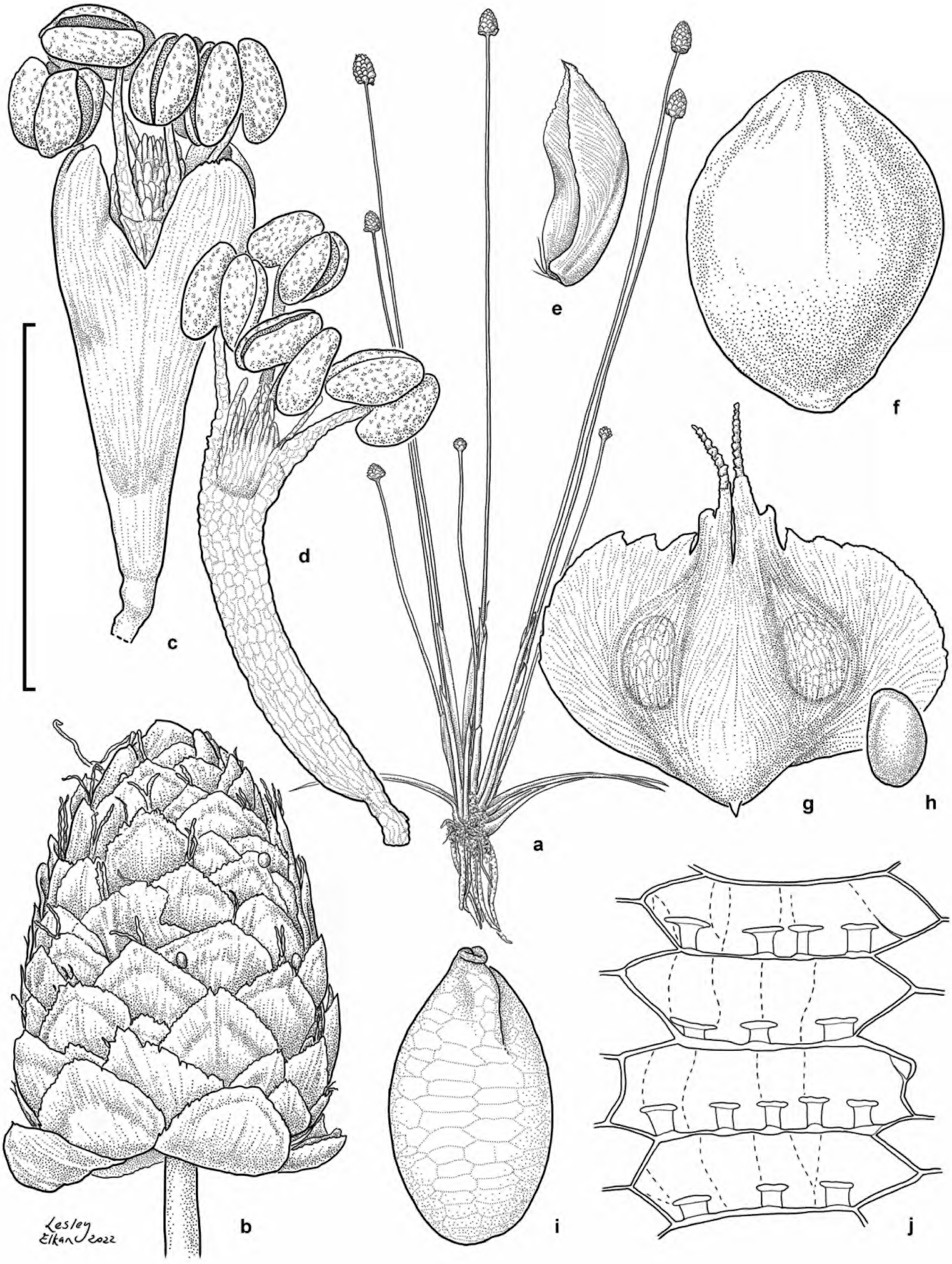

Fig. 1. *Eriocaulon insectum*. a, habit; b, inflorescence head; c, male flower with sepal; d, male flower without sepal; e, floral bract; f, involucral bract; g, female flower without petals; h & i, seed; j, seed surface. Scale bar: a = 60 mm; b = 3 mm; c & d = 0.75 mm; e–h = 1.5 mm; i = 0.5 mm; j = 0.1 mm. Voucher: *Baleeiro 631 & Jobson* (BRI).

Fig. 2. a, inflorescence of *Eriocaulon insectum*; b. inflorescence head with female petals when present (red arrow) of *E. insectum*; c, inflorescence of *E. concretum*; d, inflorescence of *E. carpentariae*; e & f, *E. insectum* habitat and habit. Scale bars shown. All images by P. Baleeiro.

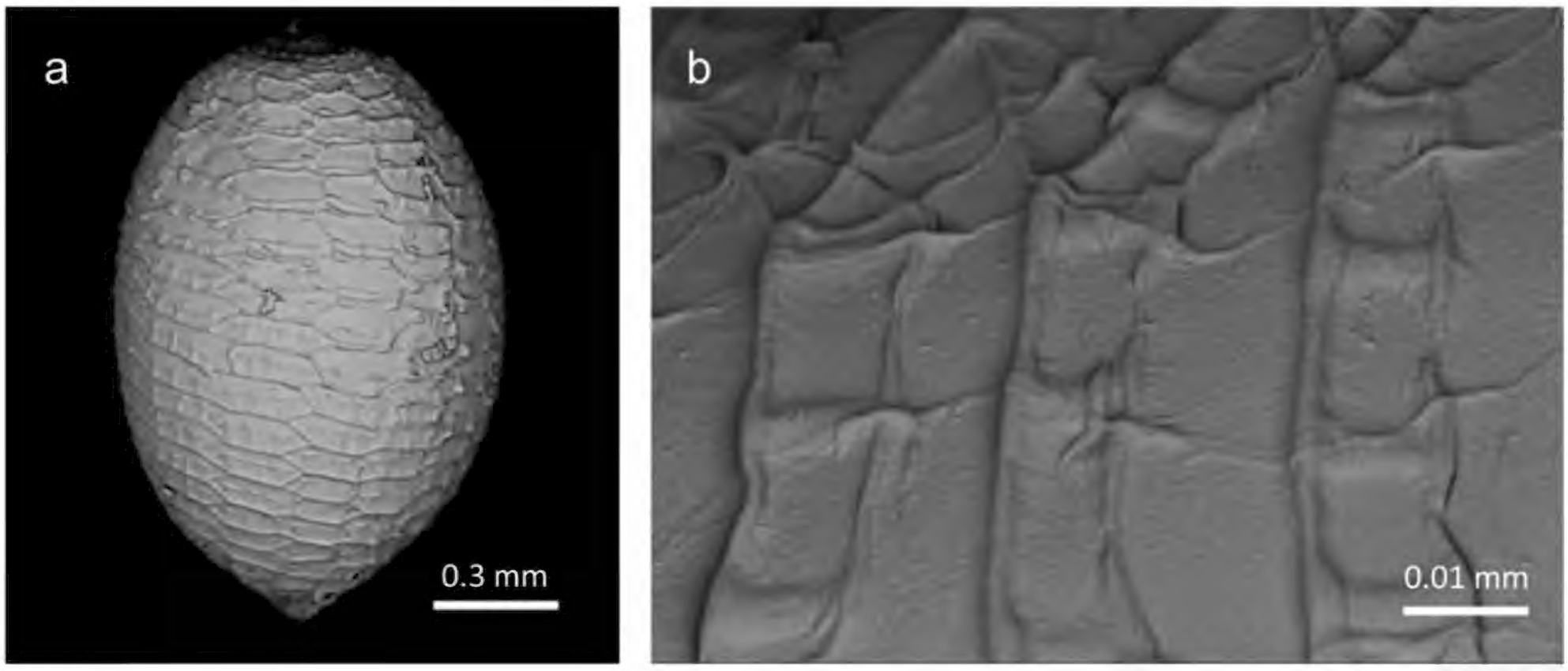

Fig. 3. *Eriocaulon insectum*. a, seed and b, seed surface. Voucher: *Baleeiro 631& Jobson* (BRI).

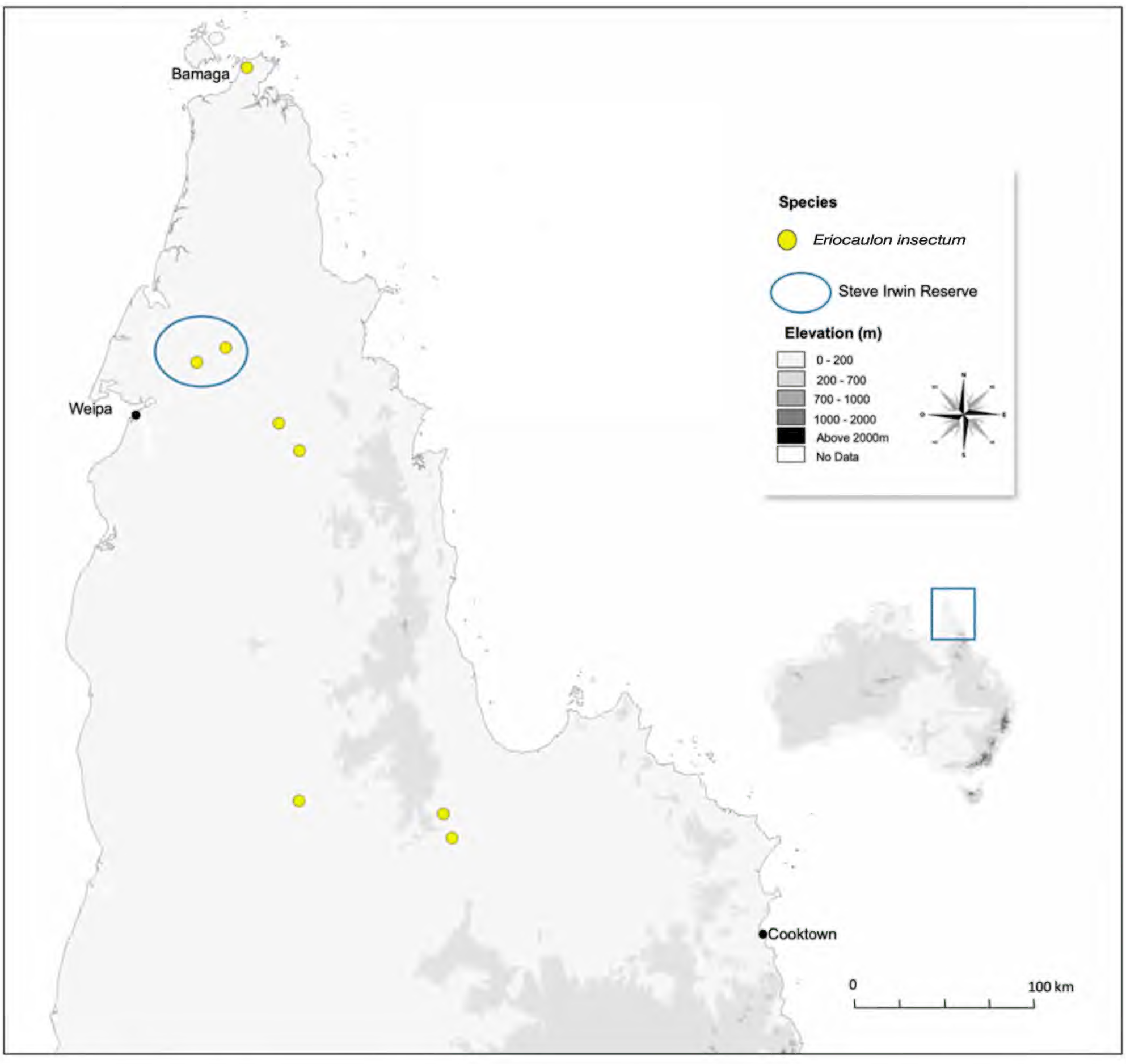

Fig. 4. Distribution map showing collection locations of *E. insectum* across Cape York Peninsula, Queensland.

Notes: *Eriocaulon insectum* is easily overlooked in the field, with its golden-brown inflorescence heads resembling co-occurring sedges, and this is presumably why it has not been collected previously. The golden-brown heads are ovoid in shape and superficially resemble those of *E. zollingerianum* and *E. hamiltonianum*. However, in addition to many other differing characters, the ovary of *E. insectum* is 2-locular vs. 3-locular, two sepals and petals vs. three, four stamens vs. six, and seed shape and surface structure with presences of peg-like projections (Prajaksood *et al.* 2012, Leach 2017, 2018).

Although our illustration of *E. insectum* shows a female flower lacking the two petals (Fig. 1g), it should be noted that petals generally dehisce during later stages of fruiting. Regardless, we have documented the petals in an image of the flower head from an earlier flowering stage (refer to red arrow in Fig. 2b). It should also be noted that male flowers of *E. insectum* have sepals fused in a spathe and opened to the base (refer to description) and visible only in frontal view. However, our illustration of the male flower (Fig. 1c) shows the rear to demonstrate the sepals are not completely fused.

Although Australian and Asian species, namely *E. carpentariae* (Australia), *E. dalzellii* Körn. (India), *E. gopalakrishnanum* K.Rashmi & G.Krishnak. (India), *E. thailandicum* Moldenke (Thailand), and *E. setaceum* L. (Pantropical) have similar seed-coat surface projections, the hyaline peg-like projections of *E. insectum* are about 3× thicker than the above species. In addition, many other characters can differentiate *E. insectum* from all five species such as the golden-brown inflorescence head, possessing four black stamens with sepals in a spathe, and female flowers with glabrous winged sepals (cf. Ansari and Balakrishnan 2009, Prajaksood *et al.* 2012, Rashmi and Krishnakumar 2014, Leach 2017, 2018).

Even though the floral morphology of *E. insectum* is most similar to *E. carpentariae* and *E. concretum*, major morphological characters such as those of the inflorescence, scape, involucre and floral bracts, female and male flowers and seeds, clearly differentiate the three species (see Table 1, Key, Fig. 2).

Table 1. Morphological character comparison: *Eriocaulon insectum*, *E. carpentariae* and *E. concretum*. n.a. = not applicable (male sepals not present).

Character	*E. insectum*	*E. carpentariae*	*E. concretum*
Plant size	10–33 cm	7–15 cm	1.5–8.5 cm
Flower head	ovoid	ovoid to hemispherical	Hemispherical
Involucral bract	concave, rounded or obtuse	flattish, lanceolate or elliptic to broadly obovate	obovate/ovate to elliptic
Receptacle	cylindrical, densely pilose	conical, sparsely hairy or glabrous	conical, sparsely hairy
Floral bract	broadly ovate, almost circular, golden apex	oblanceolate, dark apex	obovate to spathulate, black apex.
Male sepal	spathe, opened, hyaline or straw yellow	0	spathe, closed, hyaline
Anthers	exserted above sepals	n.a.	often enclosed within sepals
Female sepals	equal	Dimorphic	equal
Seed	hyaline T-shaped, peg-like projections	T-shaped peg-like projections	no projections

Moreover, new species status is supported by a preliminary molecular phylogenetic analysis using Bayesian inference on a plastid/nuclear DNA matrix that includes Asian sequences used in Larridon *et al.* (2019) and newly generated sequences representing distributions of all Australian species (Baleeiro *et al.*, in prep.). The three accessions of *E. insectum* used in the phylogenetic study form a fully supported grouping that is sister to clades of Asian taxa including *E. echinulatum* Mart., *E. zollingerianum*, *E. hamiltonianum*, and the Australian species *E. concretum* (Baleeiro *et al.*, in prep.).

Key to species of *Eriocaulon* from Cape York Peninsula (modified from Leach 2017)

1. Leaves in basal rosette **2**
1: Leaves along an elongated stem ..... ***E. setaceum***
2. Ovary 2-locular **3**
2: Ovary 3-locular **10**
3. Female sepals with broad dorsal wings **4**

3: Female sepals lacking a broad dorsal keel or wing **9**

4. Involucral bracts thin, flexible, becoming reflexed at maturity **5**

4: Involucral bracts thickened, rigid, not reflexed at maturity **8**

5. Female flowers dimorphic within head with upper flowers lacking sepals; female sepal hairs marginal **6**

5: Female flowers equal within head with all flowers having sepals; female sepal hairs on adaxial surface or absent **7**

6. Floral bracts acuminate to acute; female petals spathulate, glabrous..... ***E. carpentariae***

6: Floral bracts obtuse; female petals elliptic, pubescent..... ***E. fistulosum***

7. Herbs over 10 cm tall, floral bracts straw yellow, receptacle densely pilose, stamens exserted, female sepals with black spot, seeds with T-shaped peg-like projections.... ***E. insectum***

7: Herbs up to 8.5 cm tall, floral bracts hyaline, receptacle sparsely hairy, stamens included, female sepals with black window, seeds without projections ..... ***E. concretum***

8. Floral bracts pubescent; male sepals fused for greater part, glabrous; four stamens .... ***E. willdenovianum***

8: Floral bracts glabrous; male sepals free to fused at base, pubescent; two stamens ..... ***E. depressum***

9. Floral bracts hyaline; receptacle glabrous; stamens 4..... ***E. spectabile***

9: Floral bracts black; receptacle densely pilose; stamens 2..... ***E. wolseleyi***

10. Seed longitudinal thickenings white, prominent, thicker than transverse walls **11**

10: Seed longitudinal thickenings lacking or similar thickness to transverse walls **12**

11. Floral bracts obovate; male sepals 2, free to fused at base; female sepals equal..... ***E. pusillum***

11: Floral bracts spathulate; male sepals 3, fused but split on one side to form a spathe; female sepals dimorphic..... ***E. truncatum***

12. Anthers yellow, female petals lacking..... ***E. cinereum***

12: Anthers black, female petals present **13**

13. Female sepals with a broad, flattened dorsal wing..... **14**

13: Female sepals lacking a broad, flattened dorsal wing, at most a slight dorsal keel..... **15**

14. Involucral and floral bracts with white trichomes ..... ***E. australe***

14: Involucral and floral bracts glabrous ..... ***E. zollingerianum***

15. Receptacle glabrous to sparsely hairy **16**

15: Receptacle densely pilose **19**

16. Floral bracts with white hairs **17**

16: Floral bracts glabrous **18**

17. Epidermal cells of seeds ± isodiametric, peg-like projections on both transverse and longitudinal walls ..... ***E. scariosum***

17: Epidermal cells of seeds transversely elongated, projections only on transverse walls ..... ***E. clarksonii***

18. Seed epidermal thickenings continuous bands on transverse walls..... ***E. nanum***

18: Seed epidermal thickenings of unidirectional peg-like projections on transverse walls... ***E. athertonense***

19. Seeds with even thickenings around epidermal cells **20**

19: Seeds with peg-like projections in various arrangements **21**

20. Floral bracts aristate..... ***E. nematophyllum***

20: Floral bracts obtuse to acute, lacking arista..... ***E. pygmaeum***

21. Seed with transversely elongated epidermal cells and unidirectional peg-like projections on transverse walls **22**

21: Seed with ± isodiametric epidermal cells and with peg-like projections on all walls **23**

22. Floral bracts pubescent; male sepals pubescent; female sepals equal, pubescent ..... ***E. odontospermum***

22: Floral bracts glabrous; male sepals glabrous; female sepals dimorphic, glabrous ..... ***E. athertonense***

23. Flower heads smooth in outline; involucral bracts glabrous; floral bracts lacking pronounced arista; male sepals fused into a spathe, rarely apparently free; female sepals dimorphic ..... ***E. scariosum***

23: Flower heads squarrose in outline; involucral bracts pubescent with white hairs; floral bracts with pronounced aristate tip; male sepals free; female sepals equal ..... ***E. tortuosum***

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Pittosporum kororoense (Pittosporaceae, Apiales), a new species from Coffs Harbour, Mid North Coast of New South Wales

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Abstract

A new species of rainforest shrub, described here as *Pittosporum kororoense* Benwell (Pittosporaceae, Apiales), was recently discovered at Kororo, 3 km north of the centre of Coffs Harbour on the Mid North Coast of New South Wales. Current information on the distribution, habitat, and population of this highly localised, endemic species is presented. An updated key to *Pittosporum* species in NSW is provided.

Introduction

During a flora survey in January 2021, in preparation for translocation of the threatened species *Niemeyera whitei* (Aubrév.) Jessup (Rusty Plum) for the Coffs Harbour Bypass project, an unidentified shrub was collected at the northern end of the bypass footprint. This taxon was thought to possibly belong to the Pittosporaceae but remained unidentified until April when fruits were found. Specimens sent to the National Herbarium of New South Wales (NSW) and *Pittosporum* experts Lindy Cayzer and Robert Makinson were identified as a probable new species of *Pittosporum*. Flowers were collected in September 2021 and this material confirmed the taxon as a new species.

Unpublished genetic analysis by the Royal Botanic Gardens (RBG), Sydney, produced molecular support for the morphology-based determination of a new species of *Pittosporum* (M. Rossetto and S. Yap, RBG Sydney, pers. comm.). The new *Pittosporum* was listed in the of Australian Plant Census (APC) online database under the phrase name *Pittosporum* sp. Coffs Harbour (A.S.Benwell 342, NSW1102028).

The Pittosporaceae is an old East Gondwanan family of nine genera mainly confined to Australasia except for the largest genus *Pittosporum* with about 350 species that occur in tropical and temperate regions of Australia (19 mainland species), New Zealand (26 species), Malesia (52 species), Southeast Asia, Japan, islands in the eastern Pacific basin, including Hawai'i, and lands bordering the Indian Ocean, including Madagascar and Africa (39 species) (Cayzer *et al.* in press).

Pittosporum sp. Coffs Harbour is described here as *Pittosporum kororoense*. It is morphologically similar to the group of taxa with reduced inflorescences, mainly borne on short shoots, that now includes the small *Citriobatus* A.Cunn. ex Putt. group of taxa synonymised into the genus *Pittosporum* by Cayzer *et al.* (2000). This placement of *Citriobatus* taxa within a monophyletic *Pittosporum* has been confirmed by molecular data

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Chandler *et al.* 2007), and more recent morphological revisions by Cayzer (2021) for the *Flora of Australia* series, and Cayzer *et al.* (in press).

In eastern Australia, the *Citriobatus* group has reduced inflorescences on short, spinescent or non-spinescent shoots, followed by single or few, small fruits. The small fruits may be indehiscent, or dehiscent as in the present taxon and *P. oreillyanum* C.T.White (F.M.Bailey) L.W.Cayzer, Crisp & I.Telford. The fruits in these species are small (<12 mm long), green, yellow or orange, with thin walls and the few red seeds inserted basally in a liquid to viscid resin. In contrast to this group, the second group of *Pittosporum* taxa in this area, including *P. undulatum* Vent. and *P. revolutum* W.T.Aiton have terminal, determinate, paniculate inflorescences of larger flowers and thick walled, woody fruits >16 mm in length with multiple seeds inserted base to apex.

Methods

Specimens of *Pittosporum* sp. Coffs Harbour and co-occurring *P. undulatum* and *P. revolutum* were collected and examined under an Olympus binocular dissecting microscope, along with additional specimens of *P. multiflorum* and *P. lancifolium* from the Lismore district and Coffs Harbour Botanical Gardens.

A detailed, informal report describing the morphology of the new taxon was supplied by Bob Makinson and drawings and descriptions prepared by Lindy Cayzer. Description of the new species was prepared in consultation with the above experts. Formal identification of the taxon as a new species was supplied by the National Herbarium of New South Wales (A. Orme) and specimens of *Pittosporum* sp. Coffs Harbour were deposited at the National Herbarium of New South Wales (NSW). Targeted surveys were carried out in 2021 to record the distribution, habitat, population size and phenology of *Pittosporum* sp. Coffs Harbour, which focused on the Coffs Harbour and Kororo Basins and surrounding ranges.

In summary, *Pittosporum* sp. Coffs Harbour, named *P. kororoense* in this paper, was determined as a new species based on previous morphometric and molecular analyses of the family in Australia (Cayzer *et al.* 2000; Cayzer 2021) and overseas (Gemmill *et al.* 2001; Chandler *et al.* 2007). The unpublished genetic analysis of *Pittosporum kororoense* was performed at the Royal Botanic Garden, Sydney by M. Rossetto and S. Yap (pers. comm.).

Taxonomy

Pittosporum kororoense Benwell, ***sp. nov.***

Diagnosis: *Pittosporum kororoense* differs from other species of *Pittosporum* in eastern Australia in its short, monopodial (although clonal) growth-habit and an inflorescence in the terminal leaf whorls of 1–3 creamy yellow flowers on aggregated, reduced, short shoots, each subtended by a leaf. It appears to belong to the short-shoot taxa group of *Pittosporum*, as it has indeterminate, reduced inflorescences at the end of short shoots. The dehiscent fruits of *Pittosporum kororoense* are similar to *P. oreillyanum*, but this latter species, endemic to rain forests in the Border Ranges of NSW/Qld, is a spinose shrub with pink or mauve flowers, not creamy yellow as displayed in the new species, and has much smaller leaves. *Pittosporum kororoense* differs from its close relative *P. lancifolium* (F.M.Bailey) L.W.Cayzer, Crisp & I.Telford in having larger leaves, shorter stature, absence of spines and fruits that are dehiscent (indehiscent in *P. lancifolium*).

Type: New South Wales: North Coast: West Kororo Road, 0.9 km from the Pacific Hwy, 1.6 km from the sea, Map Ref: -30.269372° 153.123066°, 31 March 2021, *A.S. Benwell 342* (holo: NSW 1102028; iso: CANB, BRI).

Shrub to 1.2 m high, single-stemmed, rhizomatous, often growing in dense, clonal patches 1–4 metres diameter, sometimes in small aggregations (<10 stems), rarely as a lone stem; stems arising from horizontal roots. *Stems* with grey-brown bark, knobbly with many petiole/branchlet scars and short, smooth sections; branching verticillate, bi- or trifurcate, ascending; twiglets brown, glabrous, vertically ridged, lenticellate, cataphylls ± persisting at ultimate nodes; shoots non-spinescent. *Indumentum* of white T-hairs only, very sparse on leaves, denser on pedicles, otherwise plant glabrous. *Leaves* alternate but becoming whorled/congested/verticillate (through shortening of internode distances) at terminal nodes; oblanceolate to almost obovate and elliptical, up to 85–112 mm long, 22–30 mm wide, petiole up to 5–8 mm; apex acute, finely mucronate, hooked; base almost subsessile, winged to a thick triangular base; adaxial surface smooth, secondary veins slightly impressed, mid-vein in slightly raised groove; abaxial surface much paler, smooth, 7–8 pairs secondary veins, very slightly raised, tertiary venation not visible when fresh, becoming more pronounced on drying on both surfaces, reticulum faint but distinct; scattered white T-shaped hairs only; margins when fresh are flat with the apices slightly down turning, spines absent. *Inflorescences* aggregated in ultimate leaf whorls; each terminal on a slender shoot up to 10 mm long, arising from a basal involucre 1–2 mm long and wide; 1–3 single flowers,

each flower subtended by a leaf; indeterminate growth (becomes axillary as shoot develops next season); pilose with T-shaped hairs: short base, longer arm, white; flower buds bullet-shaped; pedicels pilose to 3 mm long; flowers actinomorphic, unisexual, functionally male with vestigial pistil, corolla hypocrateriform/salverform, persisting slightly tubular with the petal apices reflexing; sepals to 5 mm long, very narrow, linear/acuminate, appressed, sparsely hairy on outer surface, not recurving and not caducous; petals 10–11 mm long, 3 mm wide, initially creamy yellow becoming slightly darker yellow with age. *Male flowers*, only male flowers seen. *Stamens* 6–8 mm long. *Anthers* nearly 2 mm long, slender rectangular, apices recurving backwards revealing slits and pollen; filaments adnate to petal, joined at anthesis; pistil to 7 mm long, ovary barely differentiated, 2 mm long, on a 2 mm stipe from the basal nectary. *Style* 4 mm long with little stigmatic development. *Fruit* a sub-globose capsule held upright, 8–12 mm long, 10 mm diam, plus a 2 mm long basal, lobed nectary, dehiscence loculicidal, 4-grooved, 2-valved, pedicel elongating to 7 mm as fruit ripens; exocarp yellow, glabrous, rugulose, on a 2 mm thick, erect stalk; valves bright, glossy yellow on inside surface; fruit very rare. *Ovary* funicles inserted basally in 2 loculi; seeds 2–6 per fruit, angular to reniform, fresh seed to 5 mm long with succulent, red outer layer, sticky/resinous; valves open to 90° and held flat to present red seeds, then after seeds are taken or fall, reflexed 180° to touch pedicel and curl up. Figs 1, 2.

Etymology: Kororo is the name of the locality where the new species was found. The locality may be spelt 'Korora', as in the name of the suburb and local school, or 'Kororo', as in Kororo Nature Reserve and Kororo Basin. The latter spelling is thought to reflect more closely the original aboriginal place name (Muurrbay Language and Cultural Cooperative, Nambucca Heads, pers. comm.).

Common Name: Big Banana Pittosporum (after the tourist landmark located 0.5 km from where the new species was found).

Distribution: *Pittosporum kororoense* occurs in a small area on the northern outskirts of Coffs Harbour, within 3 km of the ocean at the eastern end of the Kororo Range and adjacent lower slopes of the Coffs Harbour and Kororo Basins. There are six known locations within this area: Jordans Creek (CHB project and private property), Kororo Nature Reserve, the headwaters of Bucca Bucca Creek in Bruxner Park Flora Reserve (Orara East State Forest), MacKays Rd and Coramba Rd (CHB project) and one further site on private property (Benwell 2022). A second population was recently found on the southern slopes of Mount Yarrahappini, 50 km south of Coffs Harbour by W. Steggall (photos confirmed by author).

Phenology: Flowers for 5–6 weeks from late August to the end of September. Flowering starts and ends abruptly. Fruit ripens March–April.

Population size: A total of approximately 70 patches of *Pittosporum kororoense* have been recorded at Coffs Harbour, containing a total of about 4,000 stems. About 30 patches or 40% of the known population is found in the narrow strip of remnant forest along 1 km of Jordans Creek at Kororo (Benwell 2022). Each patch is a discrete, dense cluster of stems that appear to be clonal so the total number of genetic individuals may be quite small.

Habitat: Recorded in *Lophostemon confertus* (Brush Box) tall wet sclerophyll forest with a well-developed rainforest understorey. Also present are *Eucalyptus pilularis* (Blackbutt), *E. grandis* (Flooded Gum) and *E. microcorys* (Tallowwood) but usually subdominant to Brush Box. The rainforest mid-stratum is composed of small to medium sized rainforest trees, 5–20 m high, including *Dysoxylum mollissimum* (Red Bean), *Cryptocarya microneura* (Murrogun), *Cryptocarya rigida* (Forest Maple), *Elaeocarpus reticulatus* (Blue-berry Ash), *Endiandra discolor* (Domatia Tree), *Synoum glanduluosum* (Scentless Rosewood), *Niemeyera whitei* (Rusty Plum), *Archontophoenix cunninghamiana* (Bangalow Palm) and *Ficus watkinsiana* (Strangler Fig). Ferns, sedges, shrubs and vines dominate the lower stratum where the *Pittosporum* grows. The soil type is a medium fertility, red-yellow clay podzol formed on metasediment. Coffs Harbour has a mean annual rainfall of approximately 1,700 mm. The proximity of Kororo to the ocean and the coastal range enhances rainfall and humidity and reduces temperature extremes. *Pittosporum kororoense* occurs in the most protected habitat in south facing gullies where soil moisture is higher and fire exposure less. Brush Box dominated forest is rare in the Coffs Harbour area, nearly all wet sclerophyll forest being dominated by *Eucalyptus*. Absence of *Pittosporum kororoense* from the western half of the Coffs Harbour Basin and further west along the Kororo Range (and elsewhere in this botanically well-surveyed region), suggests that the microclimate and topography of the Kororo area acted as a refugium for this species, enabling survival during Quaternary climatic oscillations (Benwell 2022).

Fig. 1. *Pittosporum kororoense*. A. Clonal patch of more than 200 stems. B. Root suckers, stems attached to roots. C. Single-stemmed plant about 80 cm high. D. Leaves alternate in pseudo-whorls, glabrous, sub-sessile, note persistent cataphyll. E. Flowering shrub about 1 m high, flowers in condensed, terminal inflorescences of 2–4 flowers on numerous short (spineless) branchlets. F. Terminal inflorescences of 2–4 male flowers. Images from *A.S. Benwell 342*.

Fig. 2. *Pittosporum kororoense*. A. Male flowers with tubular corolla and appressed calyx lobes. B. Branch showing short, spineless, side branches with terminal inflorescences. C. Rare ripening fruits, lobed with residual nectary disc below. D. Fruit opened by a mammal or bird in search of the seed. E. Ripe fruits are held erect on a stout pedicel, note finely warty fruit surface. F. The fruit valves dehisce widely to display red seeds against a shiny yellow background, a bird attracting strategy. G. Seeds and inside of fruit valves are coated in a sticky substance.

Breeding system: Reproduces vegetatively by sucking from roots close to existing stems to form a dense thicket of stems. A few single, isolated stems recorded during surveys may represent rare seed dispersal and seedling recruitment events. All flowers examined were found to be male, so it appears at this stage that sexual reproduction is hardly functional, and populations are maintained mainly by vegetative reproduction. About 20 developed fruits with filled out seeds were found during searches of all known patches in 2021–22, indicating that a small amount of sexual reproduction and cross- or self-pollination of flowers is still taking place. The fruits were found only in three adjoining patches in the Jordans Creek population. Australian

Pittosporum generally have unisexual flowers and a dioecious breeding system; however, occasional fruits can be found on 'male' plants (or in male populations as occurring here), and occasional flowers with fertile anthers are found in 'female' plants (Cayzer 2021). Similar variation in flower structure and sex strategy has been observed in *P. spinescens* (another member of the short-shoot group), possibly triggered by climatic conditions (Makinson 1992).

Conservation status: The NSW Threatened Species Scientific Committee has made a Determination for provisional listing of *Pittosporum* sp. Coffs Harbour (A.S.Benwell 342, NSW1102028) on an emergency basis as a Critically Endangered species in Part 1 of Schedule 1 of the NSW Biodiversity Conservation Act, 2016. The main reasons for listing were very small population size (genets not ramets), restricted distribution and the current threat from development.

Table 1: Comparison of selected morphological attributes of *Pittosporum* species found in the region from Coffs Harbour to NSW/Qld border.

	Indeterminate, short-shoot, reduced inflorescence group				Determinate, floriferous group	
	P. kororoense	***P. oreillyanum***	***P. lancifolium***	***P. multiflorum***	***P. undulatum***	***P. revolutum***
Habit	shrub	shrub/small tree	shrub/small tree	shrub	tree	shrub
Spines	no	yes	yes	yes	no	no
Short lateral shoots	yes	yes	yes	yes	no	no
Height	to 1.2 m	to 5 m	to 4 m	to 3 m	to 15 m	to 3 m
Shape	oblanceolate-elliptical	ovate to circular	elliptical, narrow-ovate	broad-ovate, circular, obovate	elliptical	elliptical-lanceolate
Texture	soft	soft	soft	leathery	leathery	soft
Size (l × w)	70–112 mm × 19–30 mm	2–10 mm × 2–5 mm	15–40 mm × 5–20 mm	3–12 mm × 2.5–8 mm	60–150 mm × 15–40 mm	50–150 mm × 15–60 mm
Petiole	1–3 mm, decurrent	1–2 mm	1–3 mm	0–2 mm	12–15 mm	5–13 mm
Pseudo whorls present	yes	no	no	no	yes	yes
Floral arrangement	terminal cluster of 1–4 flowers mostly, appearing umbel-like	axillary	axillary	axillary	terminal cluster with branching	terminal cluster
Flowers/ inflorescence	few	solitary	solitary	solitary	several to many	few to several
Flower colour	pale yellow	pink	cream	white	white to cream	yellow
Shape	globose	globose	globose	globose	globose to ellipsoid	ovoid to ellipsoid
Dehiscence	dehiscent	dehiscent	indehiscent	indehiscent	dehiscent	dehiscent
Size (diam.)	9–12 mm	7–10 mm	6–10 mm	4–10 mm	10–15 mm	12–30 mm
Colour	yellow	yellow brown	purplish-black	orange	orange	brown
Surface	rough	smooth	smooth	smooth	smooth	rough
Seed colour	red	orange to red	red	-	red brown	orange
Seeds in resin	no, scarcely	no, scarcely	yes	no, scarcely	yes	no, scarcely

Key to *Pittosporum* species in NSW (modified from key in the Flora of NSW)

1. Short shoots present; adult leaves clustered or alternate, usually not whorled at end of branches (not *P. kororoense*) 2

1: Short shoots absent; adult leaves usually appearing whorled at end of branches 10

2. Short shoots spinescent in most developmental stages; stems usually scabrid; fruit indehiscent (dehiscent in *Pittosporum oreillyanum*) 3

2: Short shoots never spinescent; stems ridged and generally glabrescent, never scabrid; fruit dehiscent, always 2- or 3-valved 7

3. Flowers with petals pale orange on inner surface and maroon on outer surface; leaves with lamina c. 6 mm long ..... ***P. oreillyanum***

3: Flowers cream-coloured; leaves with lamina greater than 8 mm long 4

4. Leaves almost orbicular; margin angular-dentate; petals hairy on inner surface; fruit orange ..... ***P. multiflorum***

4: Leaves elliptic or obovate; margin lacking angular teeth; petals glabrous; fruit green, maturing to black-brown 5

5. Leaves alternate, not stem clasping ..... ***P. lancifolium***

5: Leaves mainly clustered in groups of 3 or more, stem clasping 6

6. Leaves 8–15 mm long; fruit to 25 mm diameter, thick-walled ..... ***P. spinescens***

6: Leaves 20–25 mm long; fruit less than 10 mm diameter, thin-walled ..... ***P. viscidum***

7. Sepals with distinctive woolly fringe of hairs; flowers held below leaves on long, pendant stalks; fruit 3-valved ..... ***P. erioloma***

7: Sepals without woolly hairs; flowers held amongst leaves; fruit usually 2-valved 8

8. Leaves oblong or linear to narrowly elliptic, falcate, glabrous; petiole c. 10 mm long ..... ***P. angustifolium***

8: Leaves not falcate; petiole 2–3 mm long, flowers yellow 9

9. Leaves narrow ovate to narrow oblong, abaxial surface densely hairy ..... ***P. bicolor***

9: Leaves oblanceolate to elliptical, glabrous ..... ***P. kororoense***

10. Fruit with thick woody, often warty valves; valves >2 mm thick; shrub to c. 3 m high ..... ***P. revolutum***

10: Fruit leathery, not woody nor warty; valves c. 1–2 mm thick; tall shrub or tree to 15 m high 11

11. Leaf margin undulate, occasionally flat; lamina ovate or elliptic to narrowly obovate, 6–15 cm long, 1.5–4 cm wide, glabrous, with apex acute to acuminate; petals white to cream-coloured ..... ***P. undulatum***

11: Leaf margin flat, slightly revolute; lamina obovate to narrowly so, (3–)4–7(–9) cm long, 1.3–2(–2.5) cm wide, abaxial surface pale green with whitish hairs, with apex bluntly acute to obtuse; petals purplish red ..... ***P. crassifolium***

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Further notes on the typification of some species in *Indigofera* (Fabaceae)

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Abstract

The typification of the names of three non-endemic species of *Indigofera* in Australia is revisited. Firstly, the uncertain typification of an introduced species, *I. hochstetteri* Baker, is considered; a previous, imprecise lectotypification is recognised and a second step lectotype is designated. Secondly, an earlier error in the citation of the type of another introduced species, *I. sessiliflora* DC., is corrected and specific details of the holotype are provided. Thirdly, a lectotype is designated for *I. seticulosa* Harv. a synonym of the widespread native species, *I. colutea* (Burm.f.) Merr.

Introduction

Typification of the names of various Australian *Indigofera* species has been resolved in previous papers (Wilson 1987, Wilson & Rowe 2004, Wilson & Rowe 2008, Wilson & Rowe 2010, Wilson 2014). However, it has more recently become apparent that the typification of two names, already considered in these papers, requires clarification and these cases are addressed here, following the rules outlined in the *International Code of Nomenclature for algae, fungi, and plants* (ICN; Turland & al. 2018). Additionally, the previous typification of the name of a recent adventive species is shown to be inadequate and a second step lectotype is proposed for it.

Typifications

1. *Indigofera hochstetteri* Baker

Indigofera hochstetteri was first collected in Australia in 2004 on Mundubullangana Station, south of Port Hedland. It has been suggested (S. van Leeuwen, pers. comm.) that the species could have been in the area for many years and may even have been introduced when *Cenchrus setiger* was introduced into the Pilbara in the early 1900s, possibly from India. The species was included in the key to Western Australian species by Wilson & Rowe (2015) but not treated in full.

Indigofera hochstetteri was published by Baker (1871: 101) as an avowed substitute (*nomen novum* ICN Art. 6.11) for the illegitimate name *I. ornithopodioides* Hochst. ex Jaub. & Spach and, therefore, has the same type (ICN Art 7.4). Jaubert and Spach (1856: t. 480) published the name *I. ornithopodioides*, using the manuscript

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name Hochstetter had applied to a Schimper collection ("Hochst., in *Schimp. Plant. exs. Arab. Fel.*, N° 769") but they also cited a wide range of other collections. Two superfluous names were later published for this taxon: *I. anabaptista* Steud. ex Baker, where Baker (1876: 102) mistakenly considered a *nomen nudum* listed by Steudel (1840 :805) to be validly published, and *I. jaubertiana* Schweinf. (Schweinfurth 1896: 245).

The typification of this species has been treated in various ways in the intervening years, but no publication definitively typified the taxon. I here assess the relevant publications and make a second-step lectotypification following Art. 9.17 of the ICN.

***Indigofera hochstetteri** Baker in Oliver, Fl. Trop. Afr. 2: 101 (1871).

Indigofera ornithopodioides Hochst. ex Jaub. & Spach, Ill. Pl. Orient. 5, t. 480 (1856), *nom. illeg.*, non Schumach. (1827) nec Cham. & Schltdl. (1830).

Type citation: Crescit Arabia Felici (*Schimper*, *ex Hochstetter*), Nubia (*Kotschy*!) et Abyssinia : *W. Schimper*! "in arvis humidis incultis, alt. 3000–5000 ped.," Aug. anni 1852, nec non Maio et Julio anni 1853. (*Herb. Mus. Par.*).

Lectotype (first step: Gillett 1958: 13): "YEMEN, *Schimper* (1837) 769 isotype [*sic*] of *I. hochstetteri*."

Lectotype (second step, designated here): [Arabia felix] *Schimper 769*, 15 Feb 1836 (P barcode P02958688); isolectotypes P02958689, E00405620, E00405621, E00354935, HBG519680, HBG519679, L.2050546, L.2050547, L.2050548, MEL304459, MEL304892, MEL305138, TUB001223.

The citation by Jaubert and Spach (1856) included specimens from 'Arabia Felix' [usually taken to mean Yemen and adjacent parts of south-west Saudi Arabia], 'Nubia' [perhaps part of Sudan or Eritrea] and Abyssinia [Ethiopia]. When Baker (1871) published the replacement name, he cited the Hochstetter manuscript name and associated sheet plus Jaubert and Spach's illustrated description.

As far as I can determine, the first author to narrow the type citation was Gillett (1958: 13), who cited "YEMEN, *Schimper* (1837) 769 isotype of *I. hochstetteri*, *I anabaptista*, *I. ornithopodioides* and *I. jaubertiana*." This can be interpreted as a first step lectotypification. According to Art. 9:22 of the ICN (Turland et al. 2018), there is no requirement prior to 1 January 1990 to specify a repository in which the type is conserved. Gillett's use of the term 'isotype' is puzzling but is perhaps an indication of a specimen he considered to be common to all four homotypic names.

There are numerous duplicates of *Schimper 769*, almost all bearing labels with the following locality details: "in arenosis ad margines agrorum prope Unsert Arabiae felicis," the date "15 Febr. 36," and "Unio itiner. 1837." This last is a reference to *Unio Itineraria*, an organisation based at Esslingen, Germany, that promoted scientific endeavours and funded expeditions by Schimper and others (see https://plants.jstor.org/stable/10.5555/al.ap.person.bm000121890). Gillett has taken 'Arabia felix' to be a reference to Yemen but others have considered it a reference to south-western Saudi Arabia. I here make a second-step lectotypification, following Art. 9.17 of the ICN. Note that there is a third sheet in the Paris herbarium (barcode P02958687) that is apparently mixed since it bears labels for *Schimper 769* but also *Schimper 2295* (collected in Ethiopia and dated Sept. 1854). The sheet bears 5 elements that cannot be associated with either collecting number.

There has been longstanding uncertainty regarding the typification of *Indigofera hochstetteri* and this uncertainty has apparently persisted until today. The earliest example, indicating an alternative type, was published by Gillett himself in his later treatment of the genus in the *Flora of Tropical East Africa* (Gillett 1971: 223) where he cited a different specimen as type. In this case, he cited a specimen from Ethiopia: "N. Ethiopia, *Schimper* (P, holo.)" without providing more specific details. This was, itself, not specific, since there are numerous collections by Schimper in the Paris herbarium that were collected before the replaced synonym was published in 1856. These include, for example, specimens collected at different sites in different years but assigned the same record number, *Schimper 495*: two sheets dated Aug 1852, labelled "Abyssinie, Sera Walke/Walqua" (=Sera Wakele), and two sheets dated 24 July 1853, labelled "Abyssinie, Golleb/Gölleb" (=?Golbe). More recently, Cortés-Burns et al. (2002: 703) agreed with my assessment and cited "Yemen, 1837, Schimper 769 (P holotype)" although this, too, does not effectively indicate a type.

An alternative typification is indicated by Kotresha et al. (2012: 31), who cited "Type: Ethiopia. Province: locality, *Schimper* 495 (holotype: K!)." The intended Kew specimen, barcode K000392751, has a Paris herbarium label, is stamped "HERBARIUM HOOKERIANUM 1867" and has a slip noting that it was named by J.G. Baker in the Flora of Tropical Africa. As noted above, the provenance of the collection *Schimper* 495 cannot be determined unequivocally.

2. *Indigofera sessiliflora* DC.

This species is sparingly naturalised in Australia, probably introduced via ballast from an iron ore ship at Port Hedland in north-western Australia and first collected in 1991. The name *Indigofera sessiliflora* was published by A.P. de Candolle based on a Perrottet collection from Senegal but Wilson & Rowe (2008: 304) erred in stating the following as type: "**Holotype**: Senegal, *Perrottet s.n.* (P, *n.v.*). Isotype: BM, *n.v.*" I here provide the correct details of the type, including the barcode number.

***Indigofera sessiliflora** DC., Prodr. 2: 228 (1825).

Type citation: Senegal 'v.s. comm. a cl. Perrottet inventore'

Holotype: Senegal, *Perrottet s.n.* (G-DC, barcode G00497609). Isotype BR (barcode BR000000625514); probable Isotype: BM (barcode BM000843135) "n. 183"

The holotype consists of a single, relatively large specimen and the associated label confirms that it was collected in Senegal by Perrottet and received by de Candolle in 1825. It also indicates that it was separated from a mixed collection ("melée avec Crotalaria bracteolata de Perrottet").

3. *Indigofera seticulosa* Harv.

Harvey (1862: 196) described *Indigofera seticulosa* in *Flora Capensis*, citing an Armstrong specimen in Herb. Hooker, but noted that "the habitat of this is quite uncertain, and possibly it may not be S. African". Brown (1912: 275) first recognised this as a synonym of *I. viscosa* Lam. (=*I. colutea* (Burm.f.) Merr.), with "the type specimen being identical with Armstrong's No. 385, collected at Port Essington [Australia], and doubtless belongs to that gathering". Gillett (1958: 65) listed the name as a synonym of *I. colutea* var. *colutea* and cited *Armstrong 385* as "holotype of *I. seticulosa*, wrongly thought to be from S. Africa".

Wilson & Rowe (2010: 69) cited Gillett's "holotype" uncritically, not realising there were four sheets in the Kew herbarium. Furthermore, given that there are multiple sheets in that herbarium from this gathering, it is not possible to interpret Gillett's citation of a 'holotype' as an effective lectotypification under Art. 9.10 of the ICN.

Indigofera seticulosa Harv., Flora Capensis 2: 196 (1862).

Type citation: 'HAB. Uncertain, Armstrong. (Herb. Hooker)'.

Lectotype (designated here): Australia: [Northern Territory: Port Essington, Cobourg Peninsula] *Armstrong* [385] (K, barcode K000393277). Isolectotypes: K000393274, K000393275, K000393276.

Although there is circumstantial evidence that one of the four sheets at Kew could be interpreted as the holotype, this cannot be established unequivocally and I have taken the precautionary approach of designating a lectotype. Of those four sheets, only one (K000393275) is not in contention for lectotypification because Harvey had cited the source of his specimen as '(Herb. Hooker)' and this one is ex Herbarium Benthamianum. None of the three remaining sheets, all stamped 'Herbarium Hookerianum' bears the name *Indigofera seticulosa* in Harvey's hand but only one sheet, K000393277, lacks the locality and Armstrong's collecting number, both of which are absent from the protologue. This sheet is designated lectotype; the other sheets, all clearly part of a single gathering, are isolectotypes.

Acknowledgments

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Acacia pendula (Fabaceae: Mimosoideae) in the Hunter Valley of New South Wales: Cunningham's collection from April 1825 and its implications

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Abstract

Previous debate on the status of *Acacia pendula* A.Cunn. (Fabaceae: Mimosoideae) in the natural flora of the Hunter region of New South Wales remains unresolved. However, the discovery of a journal entry and a specimen of *Acacia pendula* collected from 'Hunter's River' by Allan Cunningham in April 1825 potentially provide evidence for its long-term presence there. Close examination of a scan of this specimen reveals a poor match to the lectotype for this species, and its infertile nature means that it cannot be positively identified using taxonomic keys. Rediscovery of a small group of *Acacia* '*pendula*' plants near to where Cunningham travelled in 1825 confirms the sterile and root-suckering habit of the species which is consistent with those growing elsewhere in the region. Despite this find, Cunningham's journal entry and collection provide no confirmation that *Acacia pendula* naturally occurred extensively in the region (although it may have been very rare) but could suggest either that he had located one of the first introduced stands of the species in the region (through indigenous people or European settlers), or that these sterile root-suckering plants represent a currently un-named taxon or un-recognised hybrid. Final resolution of Hunter Valley populations of *Acacia pendula* s. lat. may only be attained through genetic studies.

Introduction

Acacia pendula A.Cunn. (Fabaceae: Mimosoideae) in the Hunter Valley of New South Wales is legally protected as an endangered population and forms an integral part of the critically endangered Hunter Valley Weeping Myall Woodland. Previous papers have debated the place of *Acacia pendula* as a natural component of the Hunter Valley vegetation (Bell & Driscoll 2014, 2016; Tozer & Chalmers 2015, 2016), however the entity remains legally protected. Uncertainty in its position within the naturally occurring Hunter flora stems from the paucity of observations contained in the journals of early explorers (relative to those documented for outside of the Hunter), the inconsistent database record of observations and collections over nearly 200 years of European settlement (heavily skewed to recent decades following legal protection of the species in the region), and the significantly different habitat (geology, soil, rainfall, elevation) between Hunter Valley plants

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and those in more westerly districts. Hunter Valley populations are also heavily clonal and observational evidence indicates they never successfully reproduce sexually (Bell et al. 2007, Bell 2018).

The diaries of explorer-botanist Allan Cunningham are difficult to decipher (Figure 1), and the wealth of botanical (and other) information within them has been at risk of disappearing over time. Fortunately, long-term research presented in Orchard (2013, 2014) and Orchard and Orchard (2013–2018b) has been progressively transcribing and releasing a vast amount of this information for researchers. At the time, Bell and Driscoll (2014) argued that nowhere in Cunningham's diaries did he make mention of *Acacia pendula* in the Hunter Valley, and certainly not in the abundance it is perceived to have been present by some modern-day workers. The one exception noted by us at that time was a collection of *Acacia pendula* made by Cunningham at 'Hunter's River', but which we considered possibly an erroneous location and/or sufficiently morphologically distinct from that species to warrant questioning. A recent unpublished review of Cunningham's diary for his time spent around Mount Dangar in the upper Hunter Valley in April 1825, freshly transcribed by Tony Orchard, has uncovered a single previously overlooked mention of *Acacia pendula* (also recounted in Whitehead 2017). It is now appropriate that this observation, together with the 1825 collection made from 'Hunter's River' potentially linked to it, be re-examined more closely. It is noteworthy that this 1825 observation occurred eight years after Cunningham first collected the species from the Lachlan River, that specimen later designated as lectotype by Pedley (1978).

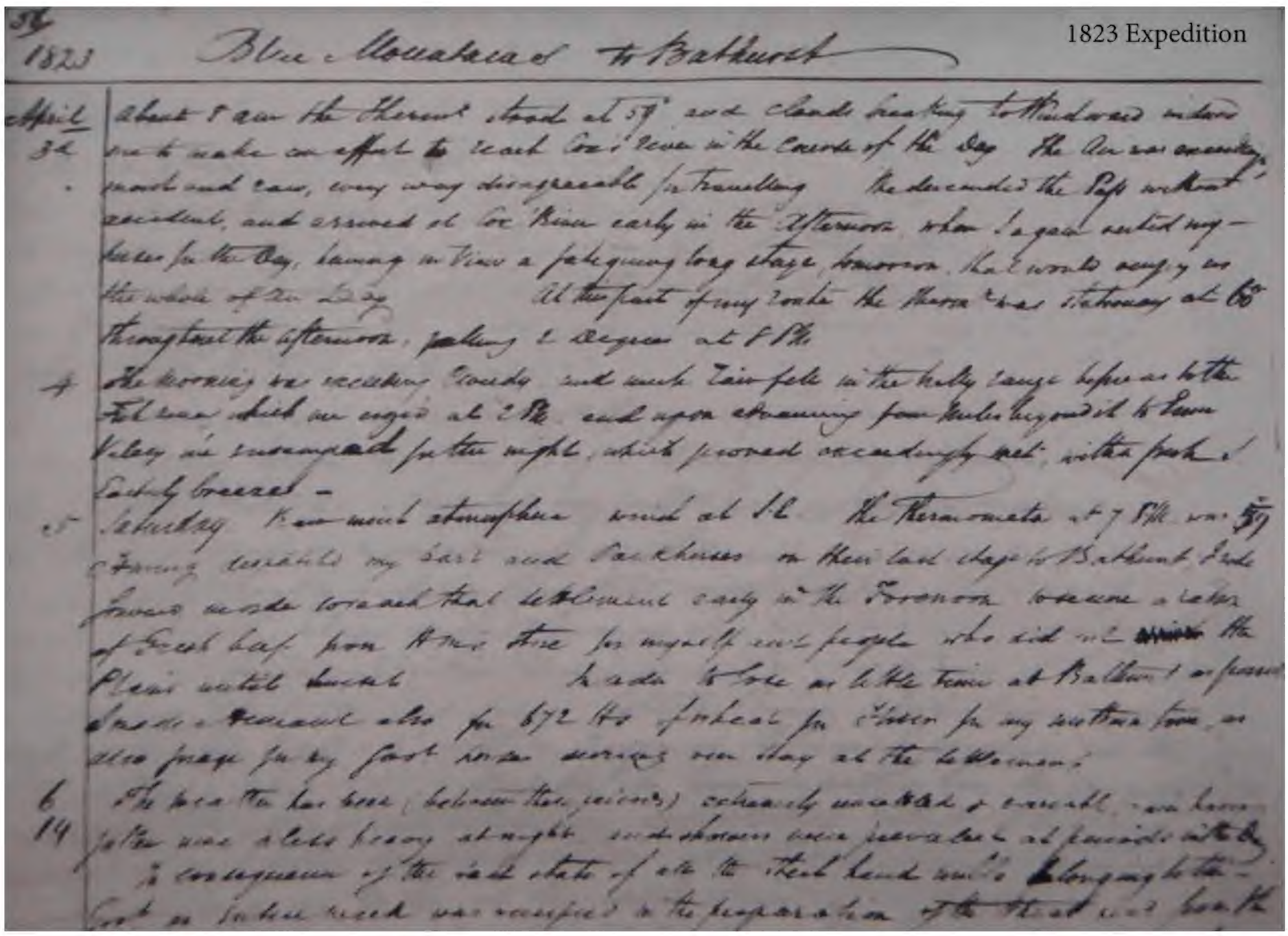

Fig. 1. An extract of Cunningham's diary from his 1823 expedition across the Blue Mountains to Bathurst.

Cunningham's April 1825 Collection

A collection of *Acacia pendula* is held within the Kew Herbarium (London), attributed to Cunningham collecting it from 'Hunter's River' in April 1825. Bell and Driscoll (2014) briefly discussed this collection, noting observable differences between it and more typical *Acacia pendula* collected elsewhere. Further, in the apparent absence of diarised notes from Cunningham concerning this species in the Hunter Valley, we suggested some uncertainty in the origin of that specimen. A comparison of the April 1825 collection of Cunningham against the lectotype for *Acacia pendula* (conveniently mounted on the same sheet at Kew) shows observable

morphological differences between the two (Figure 2, discussed below). The Hunter specimen is that shown on the left of this image (labelled as K000806169), collected from 'Hunter's River' in April 1825. The newly transcribed text from his diary entry for Sunday 24 April 1825 sees Cunningham write "*My Course for about 3 Miles was abt NNW, the land in patches exceedingly rich timbered, however with ordinary Trees of Iron bark, Blue Gum and Oak, a reedy Creek with rapid stream running easty towards the River, the flats of which being clothed with Appletree. Some soft boggy ground was covd with [?thin] grass a kind of Plantago (varia), beautiful undulated sheep-pasture [existing? axillary?] between the Hills. On the boggy flats* Acacia pendula*, assuming the arboresct growth reminded me of the Lachlan Marshes and in the grassy forest I was happy in remarking* Acacia spectabilis *likewise of that journey*" (T. Orchard pers comm). Careful assessment of his geographical position on this and the preceding days, together with mapping shown in Whitehead (2017), suggests that this observation was made near the locality of Gungal, approximately 10 km north-west of Sandy Hollow. This appears to be the only mention of *Acacia pendula* on this expedition within the Hunter Valley (T. Orchard pers comm), and it can be safely assumed that this diary entry represents the 'Hunter's River' collection.

Further examination of herbarium material shows that the lectotype for *Acacia pendula* (K000806170) was collected from the Lachlan River in 1817. This specimen has with it separately mounted pods and at least one seed, presumably from the same plant, but no flowers are present. The lectotype actually comprises four separate broken pieces that have been arranged according to growth habit during mounting. A fifth piece with pod attached has been mounted on the top left corner of this sheet, and examination of the colouration and morphology of phyllodes associated with it suggests it most likely belongs to the 1817 collection, perhaps dislodged from the lower middle section where a visible 'stub' is present. The label on this sheet was prepared by Cunningham's legatee Robert Heward and was part of the donation of Cunningham material that Heward made to Kew (T. Orchard pers comm). This label mentions three separate collections, the two noted above from Hunter's River (*Cunningham 113*, 1825) and the Lachlan River (*Cunningham 434*, 1817), and a third from Mitchells Expedition in 1835 from the "Nammoy [sic] River". The Mitchell expedition collection has been mounted separately on sheet K000806167, but lacks a precise location. Viewing of a scan of this material (Figure 3) is of interest as it shows it to be of similar colour and morphology as the 1817 collection from the Lachlan River, particularly with regard to the mucro present on the phyllode apices. Morphologically, the Hunter's River collection from 1825 bears little resemblance to either the 1817 or 1835 collections. There is a clear colour difference, the phyllodes are smaller and more closely packed along the branchlet, and apical mucros, a feature of *Acacia pendula*, are absent or poorly developed. Phyllode venation and indumentum characteristics, useful for identification purposes in this group, are not discernible on the scanned sheet. This collection is also infertile, and without viewing of pods and the alignment of seeds its identity cannot be ascertained with certainty.

To quantify some of these observations, the herbarium sheet images for the Hunter's River collection (*Cunningham 113*, 1825) and that designated as lectotype from the Lachlan River (*Cunningham 434*, 1817) were scaled to the provided scale bar and twenty measurements taken of phyllode length and width for each specimen. Mean lengths (mm) at Hunter's River were 43.6 ± 2.79 SE and at Lachlan River 55.15 ± 2.56 SE, while mean widths (mm) were 3.4 ± 0.112 SE at Hunter's River and 4.4 ± 0.222 SE at Lachlan River. A two-sample t-test showed both length ($t(38) = -3.05$, $p = 0.004$) and width ($t(38) = -4.01$, $p < 0.001$) to be significantly different between the two specimens. Phyllode density per centimetre of stem was also substantially different between the two, with two phyllodes/cm for Hunter's River and one phyllode/cm for Lachlan River.

Given that the 1817 collection has been designated as the lectotype for this species (Pedley 1978), and based on observed morphological differences and our extensive experience examining specimens in the field (both in the Hunter Valley and elsewhere), it remains unclear to us if the Hunter's River specimen is in fact *Acacia pendula*. Cunningham may have attributed his collection from the Hunter to *Acacia pendula* on an assumption, as is often done today, based solely on phyllodes without access to fertile material. Identification keys (e.g. PlantNET, https://plantnet.rbgsyd.nsw.gov.au/floraonline.htm; *Flora of Australia*, Orchard & Wilson 2001) all require an inspection of pods and seed alignment to separate this species from other similar arid-zone acacias, and without this material a conclusive identification often cannot be made. The habitat Cunningham described for the area where his *Acacia pendula* collection was made supported ironbark [=*Eucalyptus crebra*], blue gum [=*Eucalyptus blakelyi*], oak [=*Casuarina cunninghamiana*] and Appletree [=*Angophora floribunda*], with *Acacia pendula* on the 'boggy flats'. Such associated species are not typical of the species elsewhere in its range (Bell & Driscoll 2014), and indeed these species dominate remnant habitat associated with drainage lines across the bulk of the upper Hunter Valley today (pers. obs.). The absence of other collections or observations between 1825 and 1951 (the first contemporary record of the species: Bell & Driscoll 2014) in these areas by Cunningham and other observers suggests that the 'Hunter's River' collection represents an anomaly.

Fig. 2. Lectotype of *Acacia pendula* (K008086170; 1817), on the right, and the Hunter's River collection (K00806169; 1825) on the left, both collected by Cunningham. © Image copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

Fig. 3. *Acacia pendula* (K000806167) collected by Cunningham from the Namoi River on the Mitchell Expedition in 1835. © Image copyright of the Board of Trustees of the Royal Botanic Gardens, Kew.

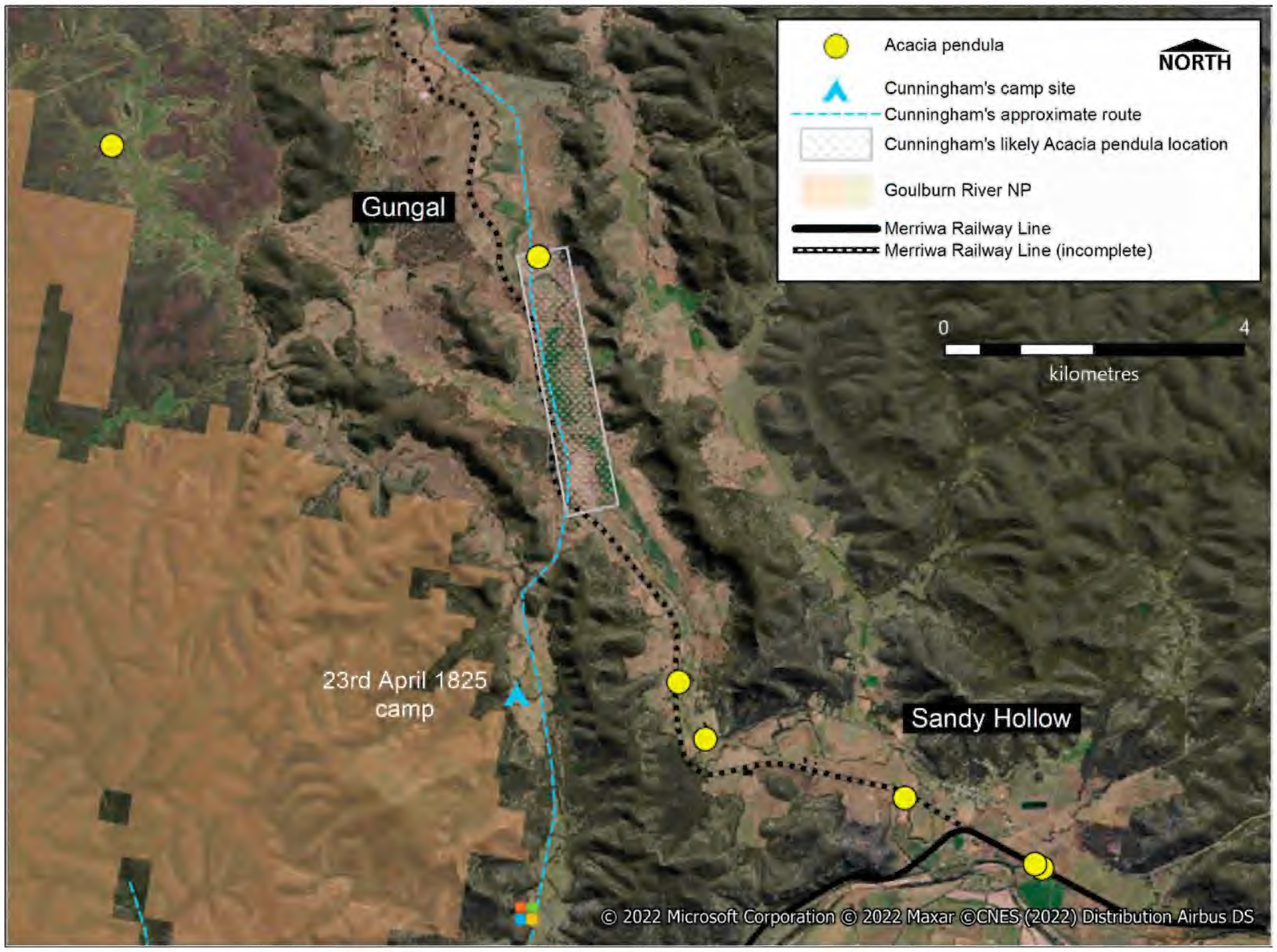

Fig. 4. Locations of relocated stands of purported *Acacia pendula* relative to Cunningham's April 1825 exploration route overlain on Google Maps imagery.

Fig. 5. Stand of *Acacia pendula* in cleared grazing land along Halls Creek, between Gungal and Sandy Hollow, now fenced to exclude grazing by cattle.

Fig. 6. Freshly collected specimen of purported *Acacia pendula* made from Worondi Rivulet at Gungal, approximately 7 km from Cunningham's collection area of April 1825. Scale bar = 4 cm.

Using the reconstructed diary notes of Cunningham and the work of Whitehead (2017), we relocated several small stands of purported *Acacia pendula* along Halls Creek between Gungal and Sandy Hollow, on or close to the route walked by him in 1825 (Figure 4). The habit and phyllodes of these trees is upright and erect (Figure 5) and phyllode morphology (Figure 6) is a good match for the material shown at left on K000806169, collected by Cunningham in April 1825 (see Figure 2). As with other occurrences in the Hunter Valley, dense stands have developed through root suckering following fencing to exclude grazing by cattle as a response to listing as a threatened population.

Implication of Cunningham's Collection

As detailed in Bell and Driscoll (2014), only horticultural specimens of *Acacia pendula* (likely originating from the Liverpool Plains) planted in the Hunter Valley flower and fruit freely, allowing confirmation of identity through examination of seed alignment within pods (i.e. transverse aligned seeds in winged pods). Other specimens (morphotypes B & C in Bell & Driscoll 2014) may flower occasionally but do not successfully set seed (Bell et al. 2007, Bell 2018), and as a result their identity as *Acacia pendula* have never been unequivocally confirmed. These plants are vigorously clonal, possibly in response to unfavourable habitat, persistent grazing or recurrent ground disturbance, and differ morphologically in their phyllodes and habit from fertile specimens (possibly neotenous). In an inspection of 48 stands of *Acacia pendula* from across the Hunter undertaken in 2007, all 12 horticultural plantings carried pods and seeds, while the remaining 'natural' specimens did not (unpubl. data). The tracking study shown in Bell (2018) found several environmental stressors acting on *Acacia* individuals, leading to a complete failure of seed production.

Cunningham's Hunter's River collection displays all the traits that are represented in morphotype C as outlined in Bell and Driscoll (2014), and as present at most of the non-horticultural specimens observed in the Hunter. These traits include the presumed infertile nature, the short, straight phyllodes with an indistinct mucro, the high density of phyllodes per branch length, and the generally upright rather than pendulous phyllode habit. It remains uncertain if this collection is *Acacia pendula*, as without fertile material (pods and seed) it is not possible to confidently distinguish it from the closely related *Acacia melvillei* and *Acacia homalophylla*, or any other related taxa. The assumption that such Hunter plants are *Acacia pendula* was largely based on observations of juvenile plants near Warkworth made by *Acacia* expert the late Terry Tame, together with mature plants growing at Jerrys Plains cemetery (T. Tame, pers. comm. 2007). Historical aerial imagery shows the Jerrys Plains plants to have been absent in 1958 (Umwelt 2006), and their presence at this location prior to that date is consequently unknown.

Daston (2004) discussed at length how the concept of the Type for a particular species must be tied to one individual specimen rather than an 'abstract idea' of a species, as was historically the more widespread practice in plant taxonomy. Whenever there is uncertainty regarding the membership of a particular specimen to a species, consultation with the Type should be undertaken. This is supported in Section 2 of the International Code of Nomenclature where it states that a Type is "*either a single specimen conserved in one herbarium or other collection or institution, or a published or unpublished illustration*" (Turland et al. 2004). In the words of Daston (2004), '*...to unsnarl a classificatory tangle requires firsthand inspection of the holotype...*'.

To our knowledge, for *Acacia pendula* in the Hunter Valley (including Cunningham's Hunter's River collection) this process has not been undertaken until now, and the absence of fruiting material has historically necessitated a 'best guess' identification with some level of uncertainty applied. Consequently, a comparison of Cunningham's 1825 Hunter's River collection with the lectotype from the Lachlan River collected in 1817 shows morphological differences between the two (detailed earlier), and it seems likely that two different taxa may be involved. Apart from those horticultural plantings which flower and fruit freely, no individuals of *Acacia pendula* from the Hunter Valley have ever been positively identified with the benefit of fruiting material, and there has been no conclusive genetic studies undertaken. This is of major concern given the species is listed as an endangered population in the Hunter Valley and it forms a key component of a critically endangered ecological community.

Examples from the literature for other taxa illustrate the importance of comparing uncertain material against their Types to resolve complex taxonomic issues, particularly for those taxa with implications for conservation management. Lorimer (2014), for example, found the threatened Tasmanian endemic grass *Rytidosperma popinense* to be well within the expected infraspecific variability of the widespread *R. fulvum* after comparison with the holotype and other collections, relegating *R. popinense* to synonymy after nearly 25 years of acceptance. In other situations, the identity of specimens within species complexes have been resolved following direct comparison to the original Type material (e.g. Ross 1974, Silverside 1991, Conn & Tame 1996, Choi & Duretto 2008). For *Acacia humifusa* Chiov., *nom. illeg.* (non *A. humifusa* A.Cunn. ex Benth.) in Africa, Ross (1974)

was able to match the features from the sterile Type of this taxon to those of *Acacia edgeworthii* T.Anderson [= *Vachellia edgeworthii* (T.Anderson) Kyal. & Boatwr.], thus reducing it to synonymy under that species. Seigler and Ebinger (2015) provided similar clarifications for some Central and South American *Acacia* (*Senegalia*). Although a possible solution for *Acacia pendula*, such an outcome is unlikely given the need for fertile material to distinguish this species from close relatives (i.e. sterile specimens of *Acacia homalophylla* and *A. melvillei* are also difficult to identify without pods).

Conclusion

Despite the mention of *Acacia pendula* in Cunningham's journal from April 1825, and after close examination of his collected material from that time including comparison with the lectotype and current-day nearby stands, there remains scant evidence that this species naturally occurred in abundance in the Hunter Valley prior to European settlement. Potentially, the species may have been naturally very rare in the Hunter Valley, existing in an atypical form in atypical habitat which might explain a lack of collection or mention in journals between 1825 and 1951, but this seems unlikely. Cunningham's collection is sterile, and his allocation to *Acacia pendula* cannot be confirmed applying modern identification keys. Morphologically, his specimen is a poor match to the lectotype, and under nomenclatural guidelines it cannot be determined as *Acacia pendula* with confidence until further supporting information becomes available.

Consequently, we see there to be three possibilities for the sterile plants currently attributable to *Acacia pendula* in the Hunter Valley. Firstly, as discussed in Bell and Driscoll (2014), propagules may have been inadvertently transported into the Hunter from the Liverpool Plains through stock movements in the early- to mid-1800s, and given the different habitat conditions and the process of time. now display neoteny or have adapted to reproduce only asexually (Eckert 2002, Barrett 2015), expanding outwards through vigorous root suckering when grazing pressure is eased. Such a pattern is evident across many stands in the Hunter and can be seen in Figure 16 of Bell (2018). Cunningham's April 1825 collection does present a quandary in this regard, given its very early collection, but he himself remarked that graziers had been present in the Hunter for over two decades by 1825 ('*since the settlement of its banks by Graziers 25 yrs elapsed*'; 23rd April 1825). Perry (1963) noted that formalised settlement commenced in the Hunter around 1813, and that by 1825 the bulk of alluvial plains along the Hunter River had already been occupied or appropriated for agricultural enterprises, with approximately 13,500 head of sheep and cattle present at this time and 6,000 acres (24 km^2) of land cleared or cultivated. It is possible that Cunningham's collection may have originated from one of the first transported propagules during the early 1800s, expressing itself as the infertile and morphologically atypical form that is now so common in the Hunter. However, it was not until 1826–1827 that stock movements onto the Liverpool Plains began (O'Rourke 2009, Hunter 2010), and by late 1829 several large stockholders regularly drove their cattle there (Perry 1963). This lessens the possibility that the plants observed by Cunningham were transported there by cattle, although movements to and from the Liverpool Plains by settlers on horseback are perhaps more likely to have successfully introduced viable seed given ungulates more effective seed dispersal abilities (e.g. Egea et al. 2022).

Secondly, trading or intentional dispersal of *Acacia pendula* by indigenous people may have facilitated introduction as has been reported for other plants (Silcock 2018). The timber of *Acacia pendula* was used to make boomerangs, spearheads and clubs (Mitchell 1838, Kamminga 1988), and many *Acacia* seed were a key food source (Gott 2008). It is plausible, therefore, that seed of *Acacia pendula* was introduced into the Hunter, but inappropriate environmental conditions impacted on growth and subsequently produced sterile, clonal plants.

A third alternative involves the possibility that a separate undescribed taxon or hybrid is present, which like *Acacia atrox* Kodela and some other arid zone *Acacia* (e.g. Andrew et al. 2003, Forrest et al. 2015, Roberts et al. 2017), reproduce only asexually. Based on current day records, such a taxon may be widespread across the Hunter but occurs in landscapes threatened by agriculture and coal mining. This view is difficult to rationalise when the diaries or collections of early botanical explorers (apart from Cunningham's April 1825 collection discussed herein), who clearly traversed much of the lands now supporting this entity (see Figure 3 in Bell and Driscoll 2014), imply its absence or rarity. As is often the case with modern-day collectors, infertile specimens may well have been bypassed by botanists, in the hope that fertile plants may still lay ahead. Confirmation of a new or hybrid taxon, therefore, may well be a possibility and may potentially resolve persistent uncertainties around the presence of *Acacia pendula* in the Hunter. Like Hunter Valley forms of *Acacia pendula*, occasional flowers in both subspecies of *Acacia atrox* never progress to fruit, and the up to 100,000 stems of subsp. *atrox* and several hundred stems of subsp. *planitiicola* Kodela & L.M.Copel. present may all be clonal from one or few individuals (Kodela 2001, Copeland and Kodela 2012). *Acacia carneorum* Maiden, thought to be closely

related to *Acacia atrox*, is also clonal and genetic studies have confirmed that the several thousand stems evident on the ground may represent just 240 individuals (Roberts et al. 2017). With such precedents elsewhere, final resolution of populations currently identified as *Acacia pendula* in the Hunter Valley is recommended for further research, with genetic assessment across all stands building on the work of Forrest et al. (2016) a priority for this and related species.

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Reinstatement of *Thysanotus elatior* R.Br. (Asparagaceae)

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Abstract

Thysanotus elatior R.Br. (Asparagaceae) is reinstated, described, lectotypified and compared with putatively related species. The species is restricted to the Top End of the Northern Territory and the Kimberley of Western Australia but was previously confused with *T. banksii* R.Br., a Queensland species. Notes are provided on the distribution, habitat, phenology, conservation status and affinities of *Thysanotus elatior*. *Thysanotus chinensis* Benth. also occurs in north-western Australia and a key to distinguish the two is provided. The application of the names *Thysanotus elatior* and *T. tuberosus* R.Br. to material there is also discussed.

Running head: Reinstatement of *Thysanotus elatior*

Keywords: Asparagaceae; Australia; Robert Brown; Systematics; Taxonomy; *Thysanotus*; Typification; Northern Territory; Western Australia

Introduction

Thysanotus tuberosus R.Br. and *T. banksii* R.Br. have both been treated as widespread and somewhat variable species in eastern and northern Australia respectively (Brittan 1981, 1987). However, study of north-western Australian specimens referred to *Thysanotus banksii* shows that they represent two distinct species (neither being true *T. banksii*), one of them formerly much confused with *T. tuberosus*. The application of names in this group therefore needs to be assessed to determine whether a new species needs to be described or not. Key to this is the name *Thysanotus elatior* R.Br., long considered a synonym of *T. tuberosus* (Baker 1876; Bentham 1878; Brittan 1981, 1987).

Robert Brown (1810: 283) described *Thysanotus elatior* from one of his own collections later labelled *Iter Australiense 5680*. However, it is now apparent that there is a discrepancy between Brown's *Prodromus*, where the protologue for *Thysanotus elatior* has Port Jackson (Sydney) area ("(J.) v.v.") as the collection locality (see also Chapman 1991: 2859; Mabberley & Moore 2022: 184), and what we conclude below, namely that the

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collection was made in the Gulf of Carpentaria in the modern-day Northern Territory. Brown (1810: 282) based his *Thysanotus tuberosus* on another of his collections (distributed as *Iter Australiense 5679*), from Port Jackson (Sydney; also as "(J.) v.v.") made in October 1803.

The descriptions of both species are very brief, as is typical in Brown's *Prodromus*, which was to have been a two-volume forerunner (hence the title of his book) of a full flora, illustrated by Ferdinand Bauer (Mabberley 1985: 160–175), and no measurements are given, save that the leaves of *Thysanotus elatior* are one to one and a half feet (c. 45 cm) long, a rather unusual feature in eastern Australian species. Baker (1876) and Bentham (1878: 42) included *Thysanotus elatior* in synonymy under *T. tuberosus*. They did not provide reasons for this, apart from commenting that *Thysanotus elatior* represented a tall, strong, many-flowered form (Bentham 1878). This treatment was followed by Brittan (1981, 1987) and CHAH (2006). Brittan (1981, 1987) considered that the type of *Thysanotus elatior* was lost.

From examining *Thysanotus* collections made by Brown, we conclude below that a collection at BM (BM000990623, *Iter Australiense 5680*, *p.p.*) from the North Coast Islands α and α1 (present day Mallison Island and Everett Island, Northern Territory) made in March 1803, is the material that he used to describe *T. elatior*. This conclusion is based primarily on (1) the length of the leaves on the material, being over 30 cm long, (2) the history of annotations on the sheet, and to a lesser extent (3) that BM files it as the type of *T. elatior*. The citation by Brown (1810: 283) under the name *T. elatior* of unspecified material from the Port Jackson area is therefore interpreted as an error.

There are other well-known examples of such geographical slips made by Brown, as pointed out by Mabberley in Mabberley & Moore (2022: 98). Bearing in mind that, within less than five years, Brown dealt with around a thousand Australian species in 464 genera (187 new) for his book, while also preparing detailed worldwide monographs of both Proteaceae and Apocynaceae, working at colossal speed (by modern standards; see Mabberley 1985: 164 & *passim*) and, without assistance, handling the vast amount of material (usually with large numbers of duplicates) he and his team had collected in Australia - all in the face of cessation of government funding (he was to pay for the printing of his book himself), it is astonishing that he did not make more errors.

In short, we have found that Brown's BM material of *Thysanotus elatior* (BM000990623 is conspecific with certain modern specimens collected from the Kimberley of northern Western Australia and the Top End of the Northern Territory. Collections from there have been variously identified as either *Thysanotus banksii* (Brittan 1981, 1987; Rye 1992) or *T. tuberosus* (Ewart & Davies 1917; Crawford 1982), but are not conspecific with collections of those, including the type of *T. banksii*, from eastern Australia. Therefore, we re-instate the name *Thysanotus elatior* for a species restricted to the Kimberley region of northern Western Australia and the Top End of the Northern Territory.

Thysanotus banksii is restricted to northern Queensland and southern parts of Papua New Guinea (reported from there as *T. tuberosus* by Jessop 1979), while *T. tuberosus* is found in Queensland, New South Wales, Victoria, and just extending into the far south-east of South Australia (see under 'Notes' below for distinctions between *T. elatior* and these species). In the monsoonal areas of northern Western Australia and the Northern Territory, there is a second species, *Thysanotus chinensis* Benth., which is widespread in northern Australia and southern New Guinea, extending north to the Philippines, Malaysia, Thailand, Vietnam and southern China (Jessop 1979; Brittan 1987).

In conclusion, original material of *Thysanotus elatior* survives at BM, and, as is argued below, it has not been typified adequately before, so this is done there. As we are reinstating *Thysanotus elatior*, we provide the first published full description, based on modern specimens.

Key to *Thysanotus* species in the Top End of the Northern Territory and the Kimberley region of Western Australia

1 Annual; roots fibrous; leaves flat to somewhat channelled; inflorescence unbranched; perianth segments 5.5–10 mm long excluding fringes ..... ***T. chinensis***

1. Perennial; roots tuberous; leaves distally terete; inflorescence branched; perianth segments (17–)20–27 mm long excluding fringes ..... ***T. elatior***

Thysanotus elatior R.Br., *Prodr.* 283 (1810).

Type citation: '(J.) v. v.' [in error for 'T.']

Lectotype: 'North Coast Islands α & α1 [y1]' [Australia, Northern Territory, Islands of the Gulf of Carpentaria, Mallison Isl. & Everett Isl.], *Anon. s.n.* [*R. Brown* and/or *P. Good*/*F. Bauer*] in *R. Brown s.n.* [*Iter Australiense*

5680, p.p.] (**BM** barcode BM000990623, second plant from right [single inflorescence with attached leaves], **lectotype designated here** – see discussion under **Typification** below).

[*Thysanotus banksii auctt. non* R.Br.: Bentham (1878: 41, *p.p.*); Brittan (1981: 90, *p.p.*; 1987: 320, *p.p.*); Dunlop (1987); Brock (1988: 319); Lazarides *et al.* (1988: 30); Rye (1992: 998–999).]

[*Thysanotus tuberosus* auct. non R.Br.: Ewart & Davies (1917: 71); Crawford (1982: 42).

Illustrations: Brock (1988: 319, Pl.); Rye (1992: Fig. 299H), both as *Thysanotus banksii*.

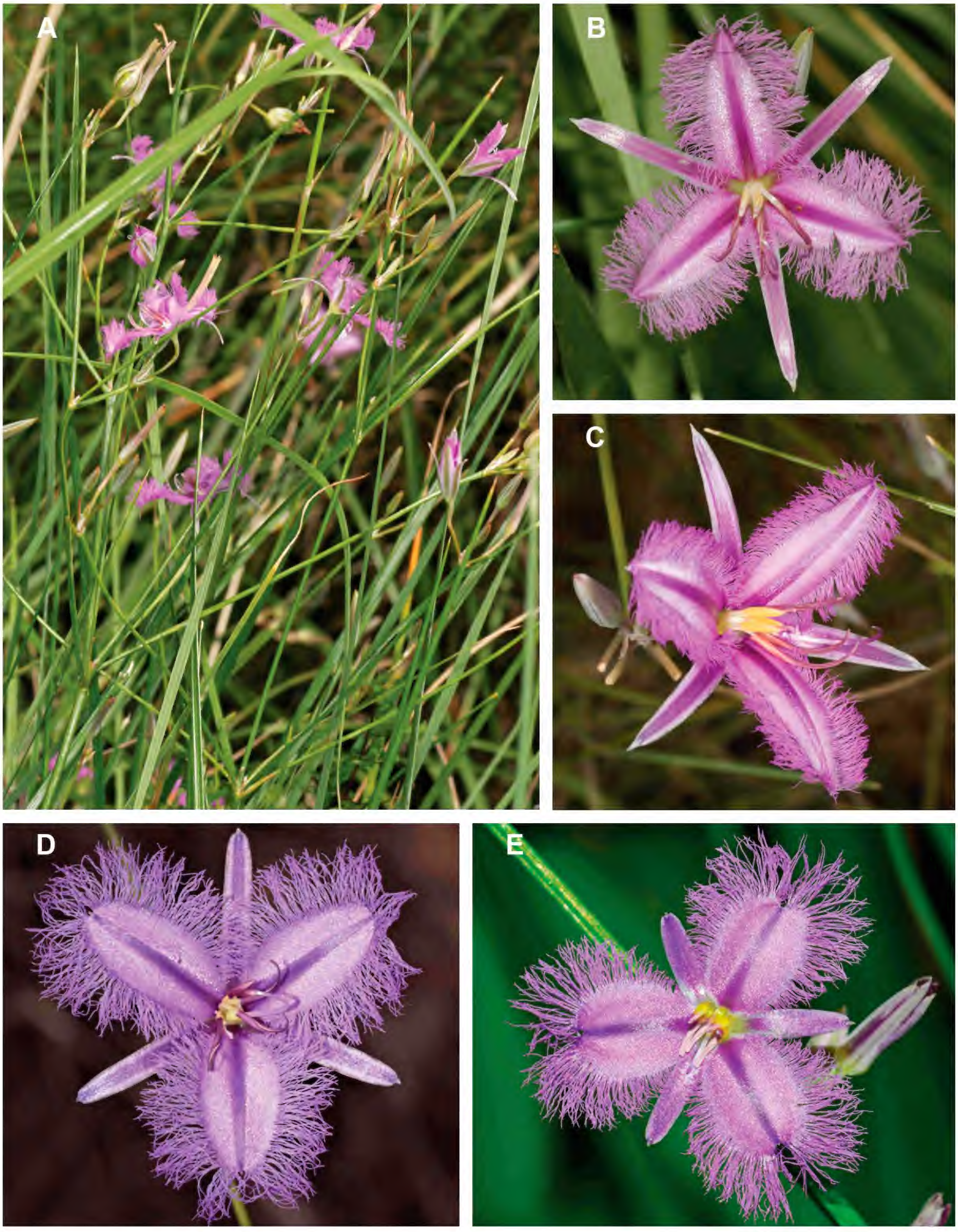

Fig. 1. A–C. Inflorescence and flowers of *Thysanotus elatior* from the north-west Kimberley, Western Australia (Voucher: *R.L. Barrett RLB 4795*, PERTH). D. *Thysanotus tuberosus* from Ku-Ring-Gai National Park, New South Wales. E. *Thysanotus banksii* from Yabi Mountain near Atherton, Queensland. Photos A–D by R.L. Barrett; E by Peter Horsfall.

Perennial geophytic herb. Rootstock small; roots tuberous; tubers cylindrical to ellipsoidal, (1.3–)3–5 cm long, 0.5–0.8 cm diameter, 2.5–3.5 cm from stock. Leaves annual, basal, 4–9(–15) of each individual plant, 35–55 cm long, 0.8–2.2 mm wide, flat adaxially, flat or slightly convex abaxially, longitudinally veined (1–)3–5 on both surfaces, glabrous; leaf sheath margins membranous, entire, 5–10 cm from the base; leaf apex obtuse. Inflorescence open paniculate, (35–)60–85 cm long; branched from (23–)44–63 cm to the base; branches 1 or 2(–5) per node, 8–21 cm long, ascending. Axes (stems and branches) terete or slightly flattened–terete in lower part, ridged with the ridges becoming more prominent distally. Umbels (3–)5–9(–13), terminal on branches and stems; outer bracts long- to short-deltoid, 3–10.5 mm long, *c.* 2 mm at base, purplish with a narrow whitish membranous margin; inner bracts short-deltoid, 1.5–5 mm long, 0.5–1.5 mm at base, purplish with a narrow whitish membranous margin. Flowers 1–3 (4), of different ages; umbels on old stems with 2–4(–9) pedicel remnants. Pedicels (0.6–)1.2–2.5 cm long at anthesis, articulate (3–)6–15 mm (one third to slightly more than halfway) from the base, erect to 90° in flower and fruit. Perianth (16–)20–25 mm long excluding fringes. Sepals lanceolate, 2.4–2.8 mm wide, pink on upper surface, light brown to brown on the under surface, 3- or 5-veined, margins pale, the apex obtuse, apiculate. Petals broadly ovate to elliptic, 18–20 mm wide including fringes, overall pink, with a darker purplish central strip on upper surface, the marginal fringe well-developed, 5.5–6.5 mm long, dense, of even length throughout except shorter at base of petal. Stamens 6, surrounding ovary, erect, the outer (antisepaline) and inner (antipetaline) whorls unequal in length; filaments 4–5 mm long; outer anthers upright, 5.5–6 mm long, yellow, occasionally with purple tips, the pores *c.* 0.8 mm long; inner anthers curving inward, 10–11 mm long, purple, the pores *c.* 1 mm long; Ovary spherical, *c.* 1.5 mm diameter, pale, with 2 ovules per locule; style terminal, 12–14 mm long, light purple; bent to one side, well-separated from the stamens and curving inwards, the stigma facing the anther apices. Capsule ±spherical or obovoid, 5–7 mm long, 4–6.5 mm wide, enclosed within persistent perianth segments adhering distally. Seeds, ±spherical 2–2.5 mm diam., black, with a brown, cap-like aril on top of navel. (Fig. 1)

Distribution: *Thysanotus elatior* is restricted to the Kimberley region of northern Western Australia and the Top End of the Northern Territory, including islands off the north coast (Fig. 2).

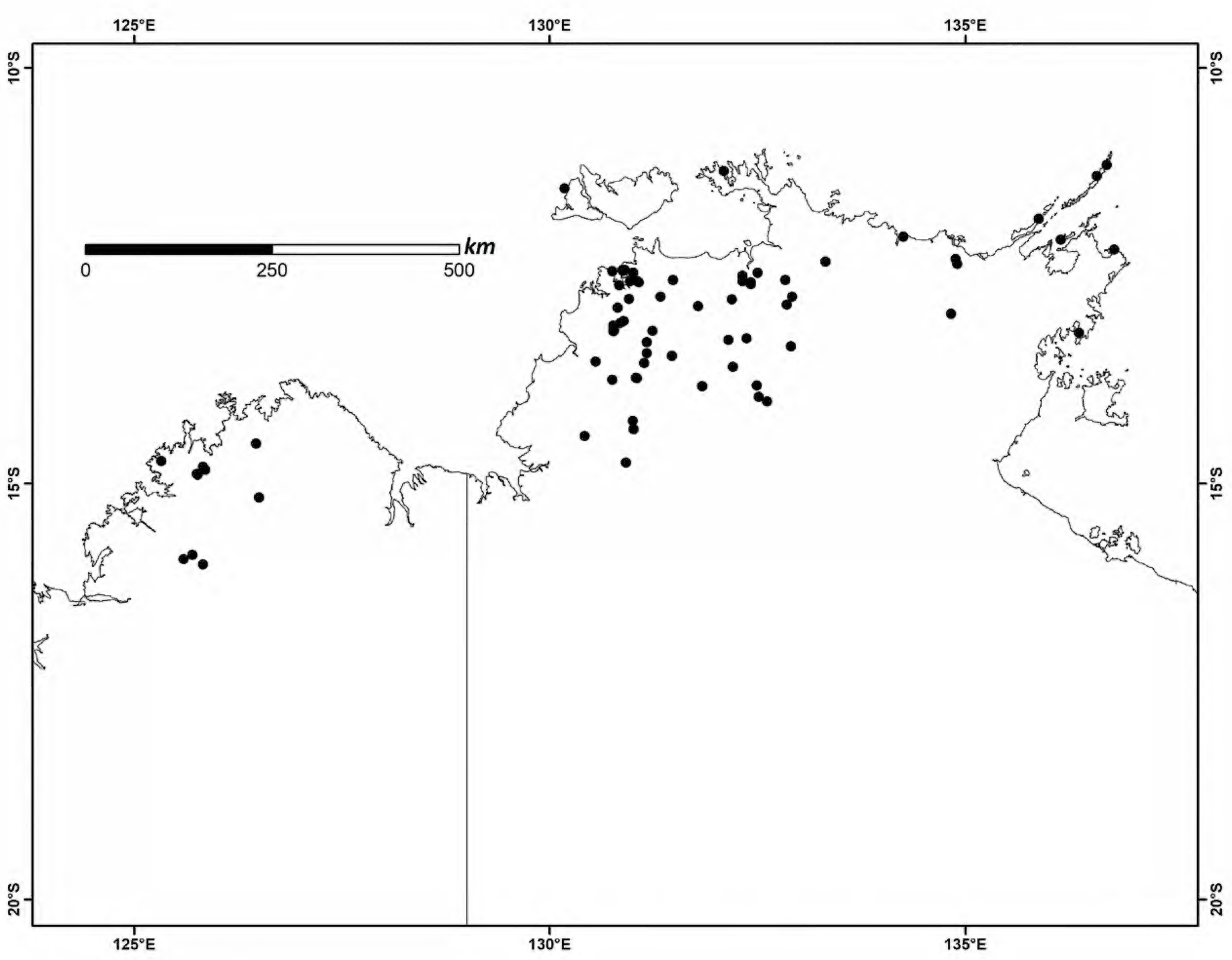

Fig. 2. Distribution of *Thysanotus elatior*.

Habitat: In Western Australia, the species is infrequently encountered but is recorded from grassland on sandstone slopes or on sandstone plateaux tops, usually in sandy soil associated with wetlands with higher organic matter. It has also been found in woodland or open woodland over sandy loam near outcropping basalt, laterite or sandstone.

In the Northern Territory, the species has been recorded from various habitats including open woodland and tall open forest, often in seasonally inundated or moist areas and often on creek banks. The soils are usually skeletal and derived from lateritic substrates including sandstone, quartz and red earths.

Selected specimens examined: WESTERN AUSTRALIA: *c.* 2.5 km NW of the Mitchell Plateau Mining Camp, Apr 1977, *Eichler 22413* (PERTH); 2.9 km SE of Mitchell Plateau Mining Camp, N Kimberley, Apr 1977, *George 14502* (PERTH); NE of Mitchell Plateau (Amax) camp, towards Lawley River, Feb 1979, *Beard 8344* (PERTH); Track S of airfield, Mitchell Plateau, N Kimberley, Jan 1982, *Kenneally 7994* (PERTH); Sandstone plateau about 30 km E of Bigge Island, Mar 1994, *Mitchell 3438* (PERTH); 9.5 km SW of junction of Pitta Creek and Prince Regent River, W Kimberley, Feb 1999, *Barrett MDB 767* (PERTH); 8.5 km ENE of Mt Agnes, near headwaters on N side of Prince Regent River, Jan 2001, *Barrett & O'Connor RLB 1569* (PERTH); 4 km SE of falls on King Edward River, Theda Station, N Kimberley, Apr 2008, *Barrett MDB 2216* (DNA, PERTH).NORTHERN TERRITORY: N Coast of Arnhem Land, *s.dat.*, *Mckinlay s.n.* (MEL 2215876); Melville Island, Apr 1986, *Johnson 4120* (BRI); 'Camp area' near Darwin, Mar 1944, *Black 1014.001 (2)* (MEL); 8 miles [18.8 km] SE Tipperary Station, Mar 1964, *Lazarides 7012* (CANB); W Woodcutters Prospect, *c.* 60 miles [96.6 km] S Darwin, Apr 1967, *Ridley 42* (BRI); 20 miles [32.2 km] S Darwin, Apr 1971, *Stewart s.n.* (CANB 218806.1); CSIRO Wildlife, Berrimah, Mar 1972, *McKean B464* (CANB, DNA, K, NT); Djamulu, Apr 1972, *Reeve 132* (CANB); Djamulu, Apr 1972, *Reeve 139* (CANB); Wessel Islands, Oct 1972, *Latz 3527* (CANB), *c.* 17 miles [27.4 km] N of Mt Evelyn, Mar 1973, *Lazarides 7991* (CANB); 2 miles [3.3 km] from Middle Arm Jetty, Darwin, Apr 1974, *Parker 412* (CANB, DNA, NT); Kapalga, Mar 1977, *Collins BC327* (CANB, DNA); Nabarlek area, Apr 1979, *Rankin 2071* (CANB, DNA); 19 km from Mary River crossing on Arnhem Highway towards Jabiru, Apr 1980, *Telford 7501 & Wrigley* (CANB); Kakadu NP, 6 km from Koongarra Saddle along track to Jabiru, Apr 1980, *Telford 8093 & Wrigley* (CANB); Whitestone Creek, Woolner Track, May 1980, *Rankin 2378* (CANB, DNA); *c.* 55 km WNW of Jabiru, Mar 1981, *Craven & Whitbread 7818* (CANB); 15 km NE Finniss River crossing along Berry Springs – 'Woolaning' road, May 1983, *Briggs 801* (CANB, MEL); Tabletop Range, Litchfield Park, Tolmer Falls track, 3.8 km from turnoff, Apr 1987, *Purdie 3417* (CANB, DNA); Litchfield National Park, Tolmer Plateau, Apr 1991, *Dunlop & Cowie 8817* (CANB, DNA); Port Essington, Kennedy Bay, Apr 1993, *Cowie 3552* (DNA, MEL); Litchfield National Park, Lost City Road, Mar 1994, *Egan 3357* (BRI).

Phenology: Flowering mainly from January to early May with mature fruits collected from February to May. However, both flowers and fruits have occasionally been recorded in July, August and October.

Conservation status: *Thysanotus elatior* is recorded as an uncommon species in Western Australia; however, as with most species in the genus, plants are conspicuous only when in flower. Recorded from the Prince Regent National Park, Mitchell River National Park, Laterite Conservation Park, Lawley River National Park and Drysdale River National Park (R.L. & M.D. Barrett, pers. obs.).

It appears to be more commonly distributed in the Northern Territory: however, this may reflect more intensive plant-collecting due to better accessibility there. It has been recorded from Charles Darwin National Park, Kakadu National Park, Litchfield National Park and Nitmiluk National Park. The species is widespread and not known to be at risk. Therefore, it is assessed as Least Concern using the IUCN (2019) criteria.

Typification: There is some confusion surrounding the typification of both *Thysanotus tuberosus* and *T. elatior*. In large part, this stems from the way Brittan's paper is formatted. The text of the citation by Brittan (1981: 170) is as follows [with equivalent formatting of indents]:

> "**44. *T. tuberosus*** R.Br., Prod. 282 (1810); Kunth, Enum. iv: 613 (1843); Baker, J. Linn. Soc. Bot. xv: 335 (1876); Benth., Fl. Aust. vii: 41 (1878) - pro parte, excluding specimens of *T. banksii*; F. Muell., Fragm, vii: 69 (1870); Brass, J. Arnold Arbor. Haw. Univ. 19: 190 (1938); Payens, Nova Guinea n.s. viii: 387 (1957); Willis, Handbook to Plants in Victoria i: 307 (1962); Burbidge & Gray, Flora of the A.C.T. 102 (1970); Beadle *et al.*, Flora of the Sydney Region 532 (1972); Brittan in Jessop (Ed.) Black, Flora of South Australia 3rd edn i: 359 (1978).
>
> *Chlamysporum tuberosum* (R.Br.) Kuntze, Rev. Gen. P1. 708 (1891).
>
> *Thysanotus tuberosus* var. *parviflora* Benth., Fl. Aust. vii: 42 (1878).

> *T. elatior* R.Br., Prod. 283 (1810) – excluding specimens of Brown from northern Queensland and the Gulf of Carpentaria, identified as *T. elatior* probably by Bennett.[1]
>
> *Typification*: It is proposed to designate the sheet of Robert Brown's collection from Port Jackson in the British Museum (Natural History) as the lectotype.
>
> *Lectotypus*: *R. Brown* (*Bennett No. 5679*), Port Jackson, *s.d.* (BM)".

In order of appearance, and the extent of the indents, it appears at first that Brittan is designating a lectotype for *Thysanotus elatior*. However, three independent names are listed, but only one type is indicated. Examination of material filed as *Iter Australiense 5679* at BM (BM 000939304; https://data.nhm.ac.uk/object/8822c434-3f66-4157-9bb2-89d9c503c861) and K (http://specimens.kew.org/herbarium/K000794764) shows that both were annotated with the epithet '*tuberosus*' by Robert Brown, Jonas Dryander and John Bennett. It is perhaps best interpreted, then, that Brittan's typification statement, despite its placing in his text (and therefore strict adherence to the Code, whatever may have been his intention, cf. Mabberley & Moore 2022: 184) is applicable to the only name accepted by Brittan, namely *Thysanotus tuberosus*. We note that Brittan did not annotate the BM sheets in any way.

While not common, it was the practice of some authors of Brittan's time to consider only the type of the accepted name relevant in a revision (e.g. Barlow 1966; Ali 1969; Blaxell 1972), and therefore not citing types of synonyms nor dealing with their typification. Examination of the preceding species, *Thysanotus triandrus* (Labill.) R.Br., shows that this was Brittan's practice in his paper. This conclusion is also supported by his later citation of germane lectotypes (Brittan 1987: 319).

Brittan's (1981: 172) discussion of the type of *Thysanotus elatior* is as follows:

> "The other problem within *T. tuberosus* is the typification of *T. elatior*. This species was seen in the living state by Brown, the locality in the 'Prodromus' was indicated by the letter 'J', and in Brown's manuscripts preserved in the Library, Botany Department, British Museum (Natural History), he records 'an hujus varietas Th. in pascuis prope fluvium Hawkesbury lectus . . .'. There is no specimen extant from the Hawkesbury River, either as a Brown-annotated or as a Bennett-distributed specimen. All Robert Brown specimens at present labelled as *T. elatior* are from the north of Queensland or else from islands in the Gulf of Carpentaria. It is therefore thought that the original type of *T. elatior* is no longer extant and that the present specimens were incorrectly identified, possibly by Bennett prior to distribution by him of Brown's specimens.
>
> "The species was reduced to synonymy by Baker (1876, p. 335) in the following terms '*T. elatior* R. Br. *est forma elata multiflora*', and also by Bentham (1878, p. 42) in the following way – '*T. elatior* R. Br. as generally understood and as probably meant by Brown when indicating Port Jackson as the station, is a tall, strong, many-flowered form, not uncommon in N.S.W. and Queensland'. Bentham then refers to the specimens in Herb. Br. and labelled as *T. elatior*, as having been collected in the Gulf of Carpentaria region and as having few-flowered umbels. It would seem then that the type of *T. elatior* was not available to Bentham when he compiled 'Flora Australiensis, vol vii'. It is the author's opinion, based on examination of the specimens of *T. tuberosus*, that the variation found in size of plant and number of flowers per umbel is so continuous that the setting up of an infraspecific taxon to correspond with Brown's concept of *T. elatior* is not possible".

In short, Britain does not typify *Thysanotus elatior*. Critical to resolve the issue is the interpretation and application of the Brown manuscripts quoted by Brittan. His text is unclear as to which Brown manuscripts he associated with particular herbarium specimens. To this end, JW re-examined the relevant materials at BM, namely herbarium specimens and associated collection slips in the Museum archives, Robert Brown's original manuscript for the *Prodromus*, and John Bennett's Register of *Iter Australiense* numbers given to Brown's collections after his death.

Examination of these materials, with the above nomenclatural issues in mind, explains the origin and interpretation of some statements made by Brittan (1981), quoted above.

1. It becomes apparent that a single sheet, *R. Brown s.n.* [*Iter Australiense 5680* – previously erroneously transcribed in the BM database as *5689*] (BM000990623) should be considered as original material of *Thysanotus elatior*. This gathering was made on islands in the Gulf of Carpentaria, now part of the Northern

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1 This is the material listed by Mabberley & Moore (2022: 184): 'T' material (BM) is 'Thysanthus [sic] A North Coast Island α [Mallison Island]', 'North Coast Island γ1 [Everett Is]' and 'Fimbriaria Is- land α1 N Coast March 4 desc 5 - 1803 rarus in Insula α March 1 [verso] Thysanotus elatior prodr. 283' (BM000990623) …… Listed with a brief description in Brown's slip B.65 66/260v numbered '4'.

Territory. The presence of two collection slips indicate that the sheet is probably mixed. According to Vallance *et al.* (2001: 379–382), Brown collected on Mallison Island on 1 March 1803 (his two 'new plants' not including any *Thysanotus* species), but he did not go to Everett Island on 4 March as he felt unwell. This means that the other gathering on the same sheet was probably made by his horticultural assistant, Peter Good, though the artist, Ferdinand Bauer, also collected some plants that day (Vallance *et al.* 2001: 381; George & Moore 2022: 123); though, again, Brown noted as 'new to us' only two species of grass. There is insufficient detail to know which parts mixed on the sheet were collected on which island, or if all material came from solely one island. On the verso of the label underneath the blue *Iter Australiense* label is written in Brown's hand 'Thysanotus elatior prodr. 283'. The verso of this label was not imaged when this specimen was digitised in 2010, due to imaging protocols in place at the time, so this critical information was absent from online data sources (Fig. 3).

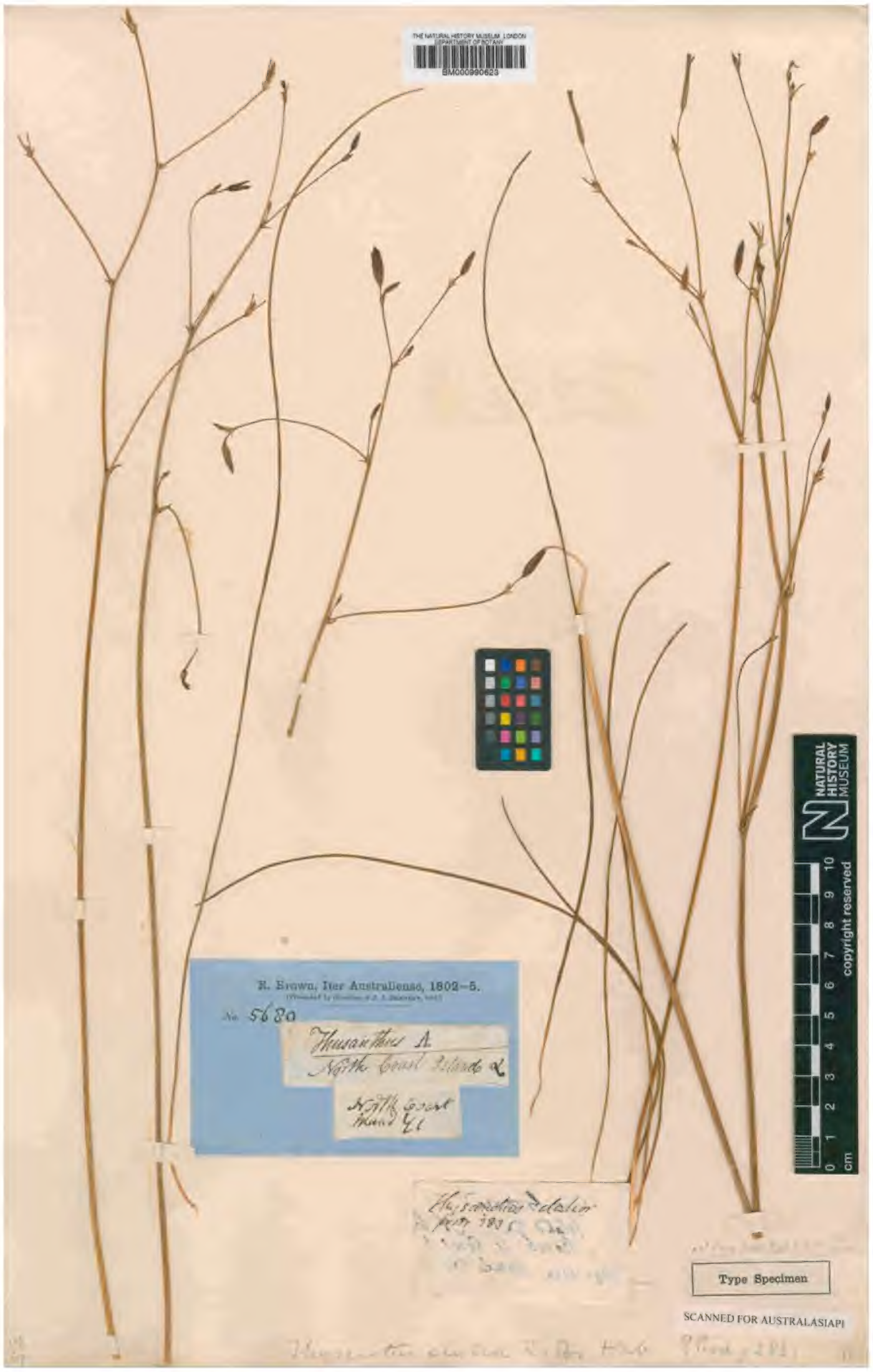

Fig. 3. Lectotype sheet of *Thysanotus elatior* R.Br. in the Natural History Museum London (BM000990623); labels showing '*Thysanotus elatior prodr. 283*' in Brown's hand on the verso of the label beneath the blue *Iter Australiense* label. The second piece from the right (an inflorescence with four attached leaves) is designated as the lectotype. Image by Jacek Wajer with permission of the Trustees of the Natural History Museum, London.

2. Brown's Latin description of *Thysanotus elatior* in the *Prodromus* is almost the same as that on the slip B. 65 66/260v (Fig. 4).

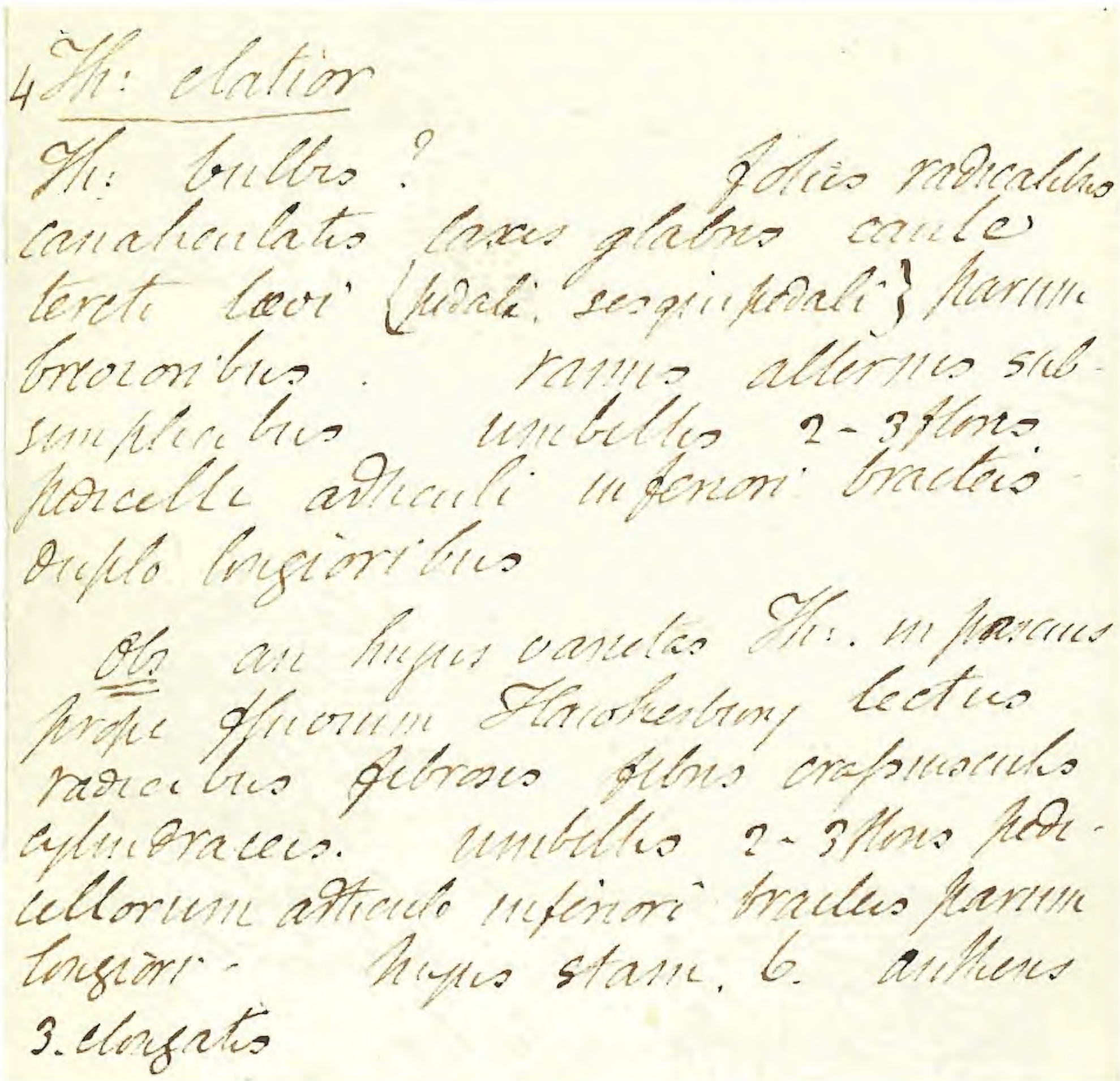

Fig. 4. Robert Brown's descriptive slip B. 65 66/260v from the Natural History Museum London (BM) archives. Image by Jacek Wajer with permission of the Trustees of the Natural History Museum, London.

3. On the same slip, Brown wrote that his *Thysanotus elatior* is probably a variety of the species of *Thysanotus* from the pastures near the Hawkesbury River (this fits Brown's observations recorded above), by which species he probably meant *T. tuberosus*, which he collected near Sydney. We can now only speculate that Brittan interpreted this as *Thysanotus elatior* being native to NSW, fitting Brown's mistaken 'J' in the protologue.
4. Bennett's list of Brown's *Iter Australiense* specimens supports this, as, under no. 5680, Bennett listed *T. elatior*, and, following Brown, added that this was likely a variety of *T. tuberosus* (Fig. 5).

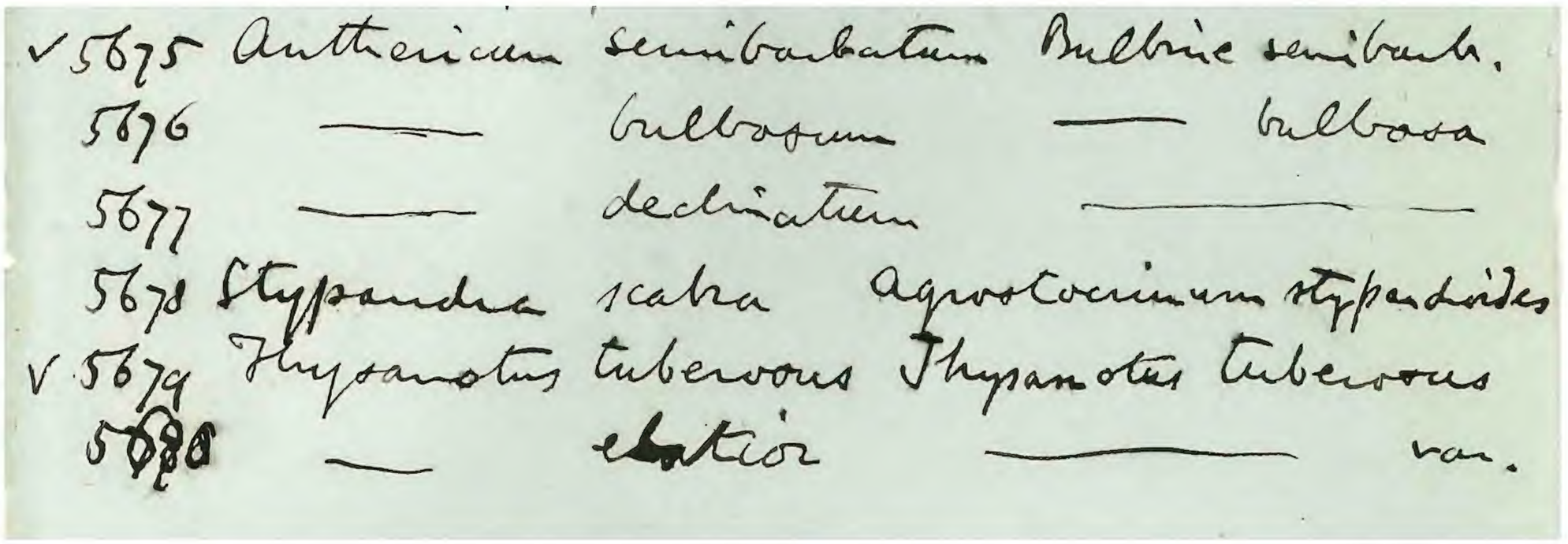

Fig. 5. Bennett's register of Brown's *Iter Australiense* specimens from the Natural History Museum London (BM) archives. Image by Jacek Wajer with permission of the Trustees of the Natural History Museum, London.

5. BM has two different gatherings mixed under *Iter Australiense 5680*, a situation that is not uncommon, as Bennett allocated numbers according to species he recognised, not giving them to individual gatherings (Mabberley in Mabberley & Moore 2022: 99). So, apart from BM000990623, which should be regarded as original material for *Thysanotus elatior*, BM000939318 is also assigned to *Iter Australiense 5680*, but this specimen is original material for *T. elongatus* R.Br., a name now considered a synonym of the Western Australian species *Thysanotus dichotomus* (Labill.) R.Br.

It is therefore apparent that Brown (1810: 283) wrote 'J' in the protologue for *Thysanotus elatior* in error (he should have had 'T') and BM000990623 (collected in the present-day Northern Territory) represents the taxon to which he applied the name *T. elatior*, Brown by then correctly considering it specifically distinct from the Hawkesbury species.

A possible syntype is held at P, namely sheet P02160140 with one specimen with leaves and an inflorescence. The label has '*Thysanotus elatior* Prodr. 283 *Port Jackson*' in the hand of Robert Brown, and 'Herbarium Richard' and 'Communicavit R Brown' in another hand typical of the herbarium of Louis Claude Marie Richard (1754–1821) whence this sheet came to P. On the face of it, this is the only authentic material including the 'J' of the protologue and should be a serious candidate for lectotypification. However, this is not a field label, but one added to the specimen once Brown's *Prodromus* was finished (Mabberley in Mabberley & Moore 2022: 98): such labels are found on almost all material of species described in the book. Brown personally presented material to Richard in October 1814 and August 1816 (Mabberley 1985: 198; Mabberley in Mabberley & Moore 2002: 96-97), making such specimens more likely to reflect his own views, than any distributed after his death. However, the shape of the inflorescence, size of the flowers, and an apparent glaucous bloom all point to this being a specimen of *Thysanotus tuberosus*, fitting the locality 'Port Jackson'. Making this the lectotype would therefore be following the conclusions of Brittan (1981). It is unclear why Brown used the name '*Thysanotus elatior*' here, given that he collected and named both species, unless he was genuinely confused, copying on to the label his mistaken locality citation for *T. elatior* in his *Prodromus,* or the confusion with other (unmounted) material could possibly have been made by Richard or whoever mounted it. Therefore, to remove all uncertainty, we have designated a single specimen on the BM sheet from north-western Australia as lectotype. As the origin of each individual piece on the sheet cannot be ascertained, we limit the lectotype to the single specimen (second from the right) with a single inflorescence and four attached leaves as the lectotype.

Notes: *Thysanotus elatior* is one of an increasing number of geophytic monocots now known to be restricted to north-western Australia (e.g. Rye 1992; Barrett & Barrett 2015, 2022, Barrett *et al.* 2015, 2021, 2022; Barrett 2018; Jones 2021). It has the largest seeds known in the genus. It has not only been confused with *Thysanotus tuberosus* (Ewart & Davies 1917), but also referred to *T. banksii* by some authors (Bentham 1878; Brittan 1981, 1987; Dunlop 1987; Lazarides *et al.* 1988; Rye 1992). It differs from *Thysanotus banksii* in the much longer perianth (20–27 mm in *T. elatior*, 8–10 mm in *T. banksii*) and much longer outer and inner anthers (5.5–6 mm and 10–11 mm in *T. elatior*, 2–2.8 mm and 3–4 mm in *T. banksii*). It differs from *Thysanotus tuberosus* in the longer perianth (12–15 mm in *T. tuberosus*), the longer filaments (4–5 mm long in *T. elatior*, 2–3 mm long in *T. tuberosus*), bright yellow outer anthers with white tips (adaxial light purplish, abaxial yellowish brown in *T. tuberosus*), and longer style (12–14 mm in *T. elatior*, 6–11 mm in *T. tuberosus*) (Fig. 1).

Our conclusions contribute to an increasing understanding of the taxonomy and relationships of Australian *Thysanotus* species (Gunn *et al.* 2020; Macfarlane *et al.* 2020; Wang & Silcock 2022), but it is apparent that further research is still required in several other species groups in this genus.

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Patersonia rosea (Iridaceae, Patersonioideae) a new species from the New South Wales central and lower north coast regions

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Abstract

Patersonia rosea Branwhite *sp. nov.* is described and illustrated, and notes provided on distribution, conservation status and habitat. Morphological differences that distinguish it from similar species of *Patersonia* are discussed, and molecular data indicating relationships are also presented.

Introduction

Patersonia R.Br. is a distinctive monophyletic genus within Iridaceae and the sole member of subfamily Patersonioideae Goldblatt (Goldblatt *et al.* 2008). Approximately 25 *Patersonia* species are recognised worldwide, the majority (18 spp.), endemic to Australia (Cooke 1986; Keighery 1990). Other species occur in Borneo, Sumatra, New Guinea, the Philippines and New Caledonia (Goldblatt *et al* 2011; Goldblatt 2012).

The number of *Patersonia* species in Australia has remained relatively stable since the publication of the Flora of Australia treatment (Cooke 1986) with only one additional species described since (Keighery 1990).

In this paper we describe a new taxon from the New South Wales central coast that was recognised as distinct in the field by one of us (BB) in the 1980s. The informal phrase name *Patersonia* sp. 'Pink' was adopted on account of its pink coloured tepals. It appears to share some features of *Patersonia sericea* R.Br. and others of *P. glabrata* R.Br., and its superficial resemblance to these taxa may explain why it has been overlooked by other workers. It sometimes co-occurs with one or both of these species, and to rule out the possibility of hybrid origin, population variability was examined in the field and molecular investigations undertaken. Although few populations are currently known and available material is limited, we here recognise the new taxon at species rank based on morphology and molecular data, to facilitate wider recognition and appropriate conservation.

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Methods

Morphology

The description presented is based on limited material and may require amendment as further collections becomes available. Floral characters were assessed on fresh and spirit material. All other characters were assessed on pressed specimens. Flowering stem and leaf width were measured at the midpoint. Filament length was measured from the point where the filament tube becomes free from the perianth to where the filaments attach to the anther base.

Taxon sampling and DNA extraction

We sampled from 41 *Patersonia* ingroup accessions comprising silica-dried and herbarium-sheet material that included broadly sampled east coast species *P. glabrata*, *P. fragilis* (Labill.) Asch. & Graebn., the two varieties of *P. sericea*, several accessions of *P.* sp. 'Pink', along with a representative of *P. macrantha* Benth. and *P. occidentalis* R.Br. from NT and WA respectively (Cooke 1986). Based on Baker *et al.* (2022), outgroup samples were selected representing a sister clade within the family Iridaceae; the three plastid markers were extracted from two complete chloroplast genomes downloaded from GenBank namely *Iris domestica* (L.) Goldblatt & Mabb. (GenBank: HSN11621) and *I.* × *germanica* L. (GenBank: NC_062594). DNA isolation was performed as for Jobson *et al.* (2017). The final dataset contained 43 accessions of which 41 were previously unpublished (Table 1). Location details of east coast ingroup accessions were used to create a distribution map (Fig. 4).

Amplification and sequencing

Amplifications were performed as for Jobson *et al.* (2017), using three non-coding plastid (cpDNA) and the nuclear (nDNA) ribosomal gene marker. The cpDNA markers included the *rps*16 intron, the *trn*D–*trn*T intron spacer (*trnD–T*), and the *matK*–5′*trnK* spacer (*matK*) that were amplified using parameters described in Shaw *et al.* (2005). The nuclear ribosomal ITS region was amplified for several samples using the forward primer ITS5A (Stanford *et al.* 2000) and the universal internal reverse primer ITS2, and reverse primer ITS4 (White *et al.* 1990). Polymerase chain reaction (PCR) conditions for ITS were performed as described in White *et al.* (1990). Despite repeated attempts to amplify the region, most samples failed due to either extreme woodiness of tissue providing low nuclear DNA concentration or inhibitory secondary compounds. Several attempts at cloning and amplifying other nuclear markers, such as ETS and *phyC*, all failed to produce plant nuclear DNA. Further experimentation is required to successfully amplify nuclear markers in *Patersonia*.

Phylogenetic analyses

Phylogenetic analyses were performed on (1) the three individual datasets, and (2) the concatenated matrix comprising all three markers. The most suitable nucleotide substitution model for each of the three markers was assessed using the Akaike information criterion (AIC) implemented in jModelTest (ver.2.1.7, see https://en.bio-soft.net/tree/MODELTEST.html, accessed 10 April 2023; Guindon & Gascuel 2003; Posada 2008). The best fit was GTR+ I+G and with a burn-in involving the first 25% of the samples, we estimated Bayesian posterior probability with five independent runs of 20 million generations, using four chains with sampling of trees every 1000 generations. All parameters were set as Dirichlet, with all other priors unlinked with a flat multinomial distribution. Stationarity was assessed by examining plots of the –lnL across generations in Tracer (ver. 1.6, Rambaut *et al.*, see https://beast.community/tracer, accessed 10 April 2023). The effective sample size (ESS) was set to >1000, and the remaining trees were used to construct a 50% majority rule consensus tree, visualised using FigTree (ver. 1.4.0; http://tree.bio.ed.ac.uk/software/figtree/).

Relevant dried and alcohol-preserved material representing all related species, held at the National Herbarium of New South Wales (NSW), Australian National Herbarium (CANB), and Queensland Herbarium (BRI) were examined.

Results

Sequences and alignment

The *rps16* matrix was 904 bp long, of which 186 characters (20%) were parsimony informative, *trnD-T* matrix was 967 bp long, of which 194 characters (20%) were parsimony informative, and the *matK* matrix was 854 bp long of which 200 characters (18%) were parsimony informative. All three datasets included members of all ingroup taxa; *rps16* (n = 39), *trnD-T* (n = 33), *matK* (n = 25) (Table 1). The concatenated three gene matrix contained 41 ingroup and two outgroup taxa and was 2725 bp long with 484 parsimony informative characters (18%).

Phylogenetic relationships

The separately analysed *rps16*, *trnD-T* and *matK* trees were largely topologically congruent, and all three datasets were concatenated and analysed together as a single matrix (Fig. 5). The 50% consensus tree showed strongly supported major clades (posterior probability (PP) = 1). The phylogeny shows that *P. glabrata* and *P.* sp. 'Pink' are each fully supported and monophyletic, and together they are sister to a clade containing *P. fragilis* and *P. sericea*. Within the *P. sericea* clade are two unsupported subclades. The single accession of *P. occidentalis* was supported as sister to *P. fragilis*, while the single representative of *P. macrantha* is nested within a paraphyletic *P. sericea* (Fig. 5).

Taxonomy

Patersonia rosea Branwhite, ***sp. nov.***

Type: New South Wales: [precise locality withheld], Charmhaven, 5 Dec 2022, *R.W. Jobson 4233* (holo: NSW 1125307 (sheet), NSW 963067 (spirit); iso: CANB, BRI).

Loosely tufted rhizomatous perennial to c. 50 cm high. Flowering stems (0.5–) 21–60 cm long, 1.5–3.0 mm wide, oval, oblong-rectangular, planoconvex or trigonous in cross-section, with a tendency to spirally twist, rigid, unbranched, leafless, the slightly raised veins usually equal to or broader than the width of the space between the veins, with a dense matted indumentum completely obscuring ground tissue but tending to dislodge in patches, usually glabrescent except proximally and ± distally; hairs mostly branched proximally, brown proximally, white above. Leaves equitant, 4–8 at base of each flowering stem in a 2-ranked fan, dull green, linear to linear-ensiform, with a tendency to spirally twist, suberect, 23–66 cm long, subequal to or slightly longer or slightly shorter (rarely much longer) than the flowering stem, 1.4–2.8 (–4.0) mm wide, pliable, narrowly acute; proximal sheathing part with matted appressed fawn-coloured hairs on the faces and longer more spreading white hairs on the hyaline true margins; blade faces with close parallel veins, the very narrow recessed intervein spaces minutely papillose, indumentum of appressed hairs not persisting ± except proximally; blade margins with appressed to ascending white hairs with fused dark brown to almost black bases, the indumentum persisting or peeling off in sections. Inflorescence a binate (rarely trinate) rhipidium, each rhipidial unit with 3–9 flowers. Outermost spathe pair 35–50 mm long; firmer-textured part greyish-brown to mid-brown, with numerous close parallel veins, indumentum of densely matted short appressed hairs persisting at least in part, rarely glabrescent in very short-stalked inflorescences; membranous margins to c. 3.5 mm wide, glabrous. Outer bracts resembling the outermost spathes but with longer more spreading hairs on the keel, ± glabrescent; inner bracts progressively becoming more predominant white than brown and with a winged keel distally, glabrous or glabrescent. Flowers radially symmetric, fugacious; floral tube white, with a hairy proximal section 5–20 mm long and glabrous distal section 15–25 mm long; tepals strongly unequal; outer three tepals spreading horizontally, pink (± violet before flowers open and/or when flowers have finished), broadly elliptic-obovate, 16–25(–30) mm long, 12–20(–25) mm wide, obtuse; inner three tepals erect, pink, obovate to obcuneate, c. 2 mm long, narrowed at base into a short claw. Stamens symmetrically disposed; filaments 3.5–5.0 mm long, virtually fully connate into a cylindrical column, white, ± tinged pink, distal free part to c. 0.5 mm long; anthers subsessile, ± oblong, 3.2–4.5 mm long, yellow, cordate basally, 2-celled, latrorse, with connective c. as broad as cells. Ovary ± cylindrical, hairy; style exerted 4–6 mm beyond apex of filament column, yellow, becoming sharply deflexed with age; stigmatic lobes fleshy, white, broadly to transversely elliptic or ovate, 1.2–1.5 mm long, densely papillose-shortly hairy. Capsules narrowly ovoid to ellipsoid or narrowly obovoid, elliptic to planoconvex or unequally trigonous in cross-section, 13–21 mm long, 4–6 mm diam., mid brown at maturity; valve external surface mostly glabrescent but remaining hairy on midvein (at least distally) and along one of both margins. Seeds c. cylindrical-fusiform to narrowly ovoid, sometimes distorted, 3.2–4.8 mm long, pale brown, finely and closely striate, rounded and abruptly curved at attachment end; aril extending from the non-attachment end of the seed along one side of the seed to almost the opposite end, linear, closely appressed to the seed, cream-stramineous when dry. Figures 1, 2.

Diagnostic characters: Distinguished from other *Patersonia* spp. by the combination of the following characters: flowering stems usually slightly longer or slightly shorter (rarely much shorter) than the leaves and with a dense matted indumentum that tends to come off in patches except proximally and ± distally; leaves strictly basal, with flat blades mostly to 2.8 (–4.0) mm wide, hairy at least initially though often glabrescent; outermost spathe pair 35–50 mm long, the firmer-textured greyish-brown to mid-brown part with a partially persistent indumentum of densely matted short appressed hairs; floral tube hairy proximally; tepals pink; staminal filaments virtually fully connate into a cylindrical column; ovary hairy; seeds cylindrical-fusiform to narrowly ovoid, 3.2–4.8 mm long, pale brown, finely and closely striate, lacking a pit at one end, with a pale linear aril extending along one side of the seed for almost its entire length.

Table 1. Accessions used in the three-gene matrix. Secondary collectors are not included. Locality abbreviations: ACT, Australian Capital Territory; NSW, New South Wales; NT, Northern Territory; Qld, Queensland; Tas., Tasmania; WA, Western Australia. GenBank numbers for each gene region are shown. Previously published sequenced not shown; NS indicates a sequence that either failed or was not included in the study. PLR = precise location removed for conservation reasons.

Code	Herbarium #	Taxon	Collector	Coll. date	Location	co-ords S	co-ords E	rps16	trnDT	matK
P01	CANB 955810	*P. glabrata*	Albrecht 16513	27/03/2022	NSW, Mt Budawang Rd, 2.29 km due N of Mt Budawang summit	-35.459444	149.994722	OQ851008	OQ851047	OQ850985
P02	CANB 955815	*P. glabrata*	Albrecht 16518	17/04/2022	NSW, Intersection of Wallagoot Lake Rd & Saphire Coast Rd	-36.766944	149.921944	OQ851009	OQ851048	OQ850986
P03	CANB 955829	*P. glabrata*	Albrecht 16534	26/04/2022	NSW, c 260m NW of the junction of Mines and Bucklands Rds	-37.445278	149.839167	OQ851010	OQ851049	OQ850987
P04	CBG 9504016	*P. glabrata*	Gilmour 7098	5/09/1990	NSW, Upper Bellinger River, near Bishops Creek	-30.408333	152.616667	OQ851011	OQ851050	NS
P05	CANB 865101	*P. glabrata*	Pedersen 1269	3/09/2013	Cult Booderee Bot Gardens ex Yattta Yatta, Little Forest Rusden Head Track	-35.280556	150.3175	OQ851012	OQ851051	NS
P06	CANB 876116	*P. glabrata*	Purdie 9555	2/09/2014	NSW, Highway 33 N of Sydney, just S of Cooks Road turnoff, Glenworth Valley	-33.403056	151.2125	OQ851013	OQ851052	OQ850988
P07	CANB 744474	*P. glabrata*	Fethers 135	15/11/2006	NSW South Coast, Twelve Mile Road, towards Boyd Lookout	-35.165278	150.439444	OQ851014	OQ851053	NS
P08	CANB 955812	*P. fragilis*	Albrecht 16515	27/03/2022	NSW, Mt Budawang summit	-35.479722	149.995278	OQ851015	OQ851054	OQ850989
P09	CANB 918642	*P. fragilis*	Branwhite sn	11/12/2019	NSW, Charmhaven, Mona Road, c. 540 m W of the Arizona Rd intersection	-33.23	151.484167	OQ851016	OQ851055	OQ850990
P10	CBG 8914064	*P. fragilis*	Jones sn	7/12/1989	NSW, Bullock Creek, c. 1 km along Point Lookout road.	-30.466667	152.3	OQ851017	OQ851056	OQ850991
P11	CANB 510773	*P. fragilis*	Mant 54	3/11/1998	Victoria, Grampians, swamp area along Hamilton Water Supply pipeline	-37.453611	142.19	OQ851018	OQ851057	OQ850992
P12	CANB 885932	*P. fragilis*	Purdie 10449	20/10/2015	TAS, Arthur Highway, Port Arthur	-43.1425	147.846111	OQ851019	OQ851058	OQ850993
P13	CANB 952306	*P. sericea* s.lat	Braby 224	27/12/2020	NSW, Tallaganda National Park, 7.6 km E of Huskinstown	-35.410833	149.536667	OQ851020	OQ851059	OQ850994
P14	CANB 955816	*P. sericea* s.lat	Albrecht 16519	17/04/2022	NSW, Intersection of Wallagoot Lake Rd & Saphire Coast Rd	-36.766944	149.921944	OQ851021	OQ851060	OQ850995
P15	CANB 918641	*P. sericea* s.lat	Branwhite sn	11/12/2019	NSW, Charmhaven, W of the intersection of the Pacific Hwy & Windermere Ave	-33.223611	151.498056	OQ851022	OQ851061	OQ850996
P16	CANB 527799	*P. sericea* s.lat	McDougall 694	12/11/1999	NSW, Bittangabee Bay, Ben Boyd National Park	-37.223889	150.018056	OQ851023	OQ851062	NS
P17	CANB 617293	*P. sericea* s.lat	Donaldson 2416	19/09/2000	NSW, Pilliga Nature Reserve, 1.4 km E of Borah Creek Road	-30.863333	149.533611	OQ851024	OQ851063	OQ850997
P18	CANB 449596	*P. sericea* s.lat	Moore 9342	22/10/1992	NSW, Apex Park on Gwydir Highway 1.8 km E of Warialda	-29.6	150.683333	OQ851025	OQ851064	NS
P19	CBG 7703024	*P. sericea* s.lat	Crisp 2969	12/06/1977	QLD, Leichhardt District, Blackdown Tableland, WNW of S. Mimosa Ck falls	-23.783333	149.016667	NS	OQ851065	OQ850998
P20	NSW963073	*P. sp. 'pink'*	Branwhite A	11/12/2019	NSW, Charmhaven, site A	PLR	PLR	OQ851026	OQ851066	OQ850999
P21	CANB 914168	*P. sp. 'pink'*	Branwhite B	11/12/2019	NSW, Charmhaven, site B	PLR	PLR	OQ851027	NS	OQ851000
P22	CANB 914169	*P. sp. 'pink'*	Branwhite C	11/12/2019	NSW, Charmhaven, site C	PLR	PLR	OQ851028	OQ851067	OQ851001
P23	CANB 914170	*P. sp. 'pink'*	Branwhite D	11/12/2019	NSW, Charmhaven, site D	PLR	PLR	OQ851029	OQ851068	OQ851002
P24	CANB 918640	*P. sp. 'pink'*	Branwhite sn	11/12/2019	NSW, Charmhaven, site F	PLR	PLR	OQ851030	OQ851069	OQ851003

Code	Herbarium #	Taxon	Collector	Coll. date	Location	co-ords S	co-ords E	rps16	trnDT	matK
P25	CANB 955854	*P. sericea* s.lat	Albrecht 16559	2/01/2021	NSW Property of Joe McAuliffe, SE of the intersection of Nerriga Rd	-35.158333	150.156389	OQ851031	OQ851070	OQ851004
P26	CANB 660108	*P. sericea* s.lat	Purdie sn	31/10/2004	NSW, Nadgigoma National Park, Eurodux Fire Trail	-35.313889	149.822222	OQ851032	OQ851071	OQ851005
P27	CANB 795386	*P. sericea* s.lat	Percival 19	7/10/2010	NSW, Southern Highlands; Penrose State Forest.	-34.632778	150.211667	OQ851033	NS	OQ851006
P28	CANB 712675	*P. sericea* s.lat	Johnstone 2235	18/11/2007	NSW, Old Bathurst Road between Mt Riverview and Emu Plains	-33.742222	150.641111	OQ851034	NS	OQ851007
P29	CBG 8602971	*P. sericea* s.lat	Parris 8936	22/02/1986	NSW, 9 km SW of Pambula, NW of Nethercote, NW of `Ocean View'	-36.966667	149.783333	OQ851035	NS	NS
P34	AQ641675	*P. glabrata*	Bean 10935	5/10/1996	Qld, Darling Downs Hellhole Gorge, NE of Yangan	-28.123408	152.376087	OQ851036	NS	NS
P36	AQ836291	*P. sericea* s.lat	Forster 39987	28/06/2013	Qld, WB Bullyard Conservation Park	-24.965833	152.048611	OQ851037	NS	NS
P37	AQ606631	*P. glabrata*	Forster 24690	6/09/1999	Le Palmgrove NP NW of TAROOM	-25.050556	149.278889	OQ851038	NS	NS
P39	AQ748679	*P. fragilis*	Stephens 2509077	25/09/2007	Qld, Mo Lamberts Swamp Nth Stradbroke	-27.6425	153.443056	OQ851039	OQ851072	NS
P40	AQ839630	*P. fragilis*	Forster 43453	16/12/2015	Qld, WB Wide Bay training area, Tin Can Bay track	-25.924444	152.966111	OQ851040	OQ851073	NS
P41	AQ671554	*P. glabrata*	Forster 23757	4/11/1998	Qld, Le Palmgrove NP NW of Taroom	-25.050556	149.278889	OQ851041	NS	NS
P42	AQ850358	*P. sericea* s.lat	Booth 5425	24/09/2009	Qld, PC Eurimbula NP	-24.153333	151.78	OQ851042	OQ851074	NS
P43	AQ458833	*P. macrantha*	Forster 6070	23/11/1989	NT, Finnis River Crossing	-12.983333	130.75	OQ851043	NS	NS
P44	AQ465625	*P. occidentalis*	Smith 1063	18/08/1988	WA, Hindmarsh Rifle range	-31.316667	117.133333	OQ851044	OQ851075	NS
P45	AQ915827	*P. glabrata*	Halford QM1014	18/02/2014	Qld, Shoalwater Bay Training Area, Clinton Sector, Mount Westall.	-22.363333	150.58	OQ851045	OQ851076	NS
P46	AQ831259	*P. sericea* s.lat	Halford QM486	17/04/2011	Qld, Shoalwater Bay Training Area, Mount Parnassus sector,	-22.782222	150.579167	OQ851046	OQ851077	NS

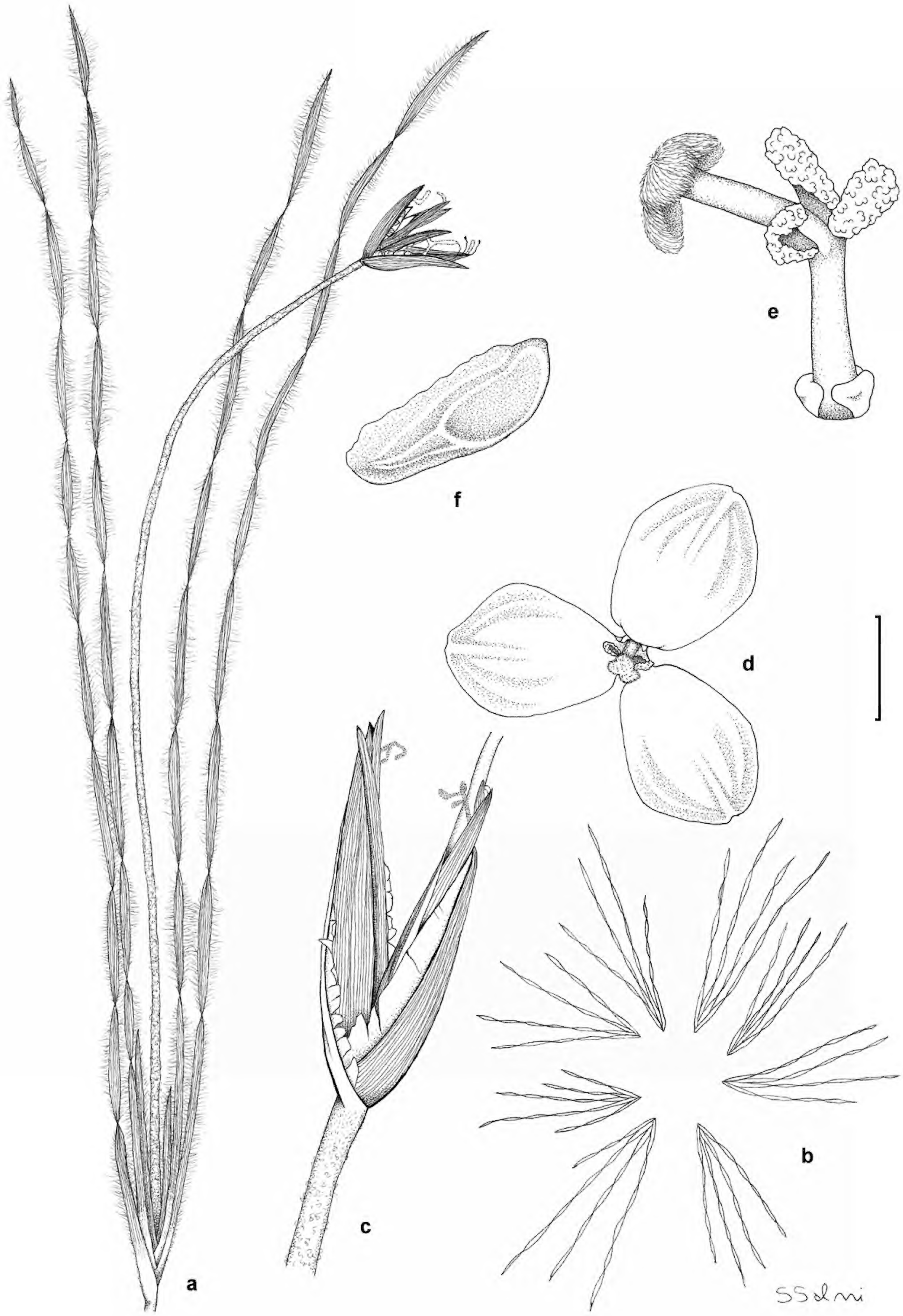

Fig. 1. *Patersonia rosea*: **a.** habit; **b.** arrangement of leaf-bearing shoots in mature plant (plan view); **c.** inflorescence showing outermost spathe pair; **d.** flower showing prominent outer 3 tepals; **e.** inner tepal whorl (at base), filament column, anthers, style and stigmatic lobes; **f.** seed. Scale bar: a = 30 mm; b = 3 mm; c = 13 mm; d = 10 mm; e = 2.5 mm; f = 2.3 mm. Illustration by S. Salmi (*B. Branwhite* s.n., 18 Dec 2022).

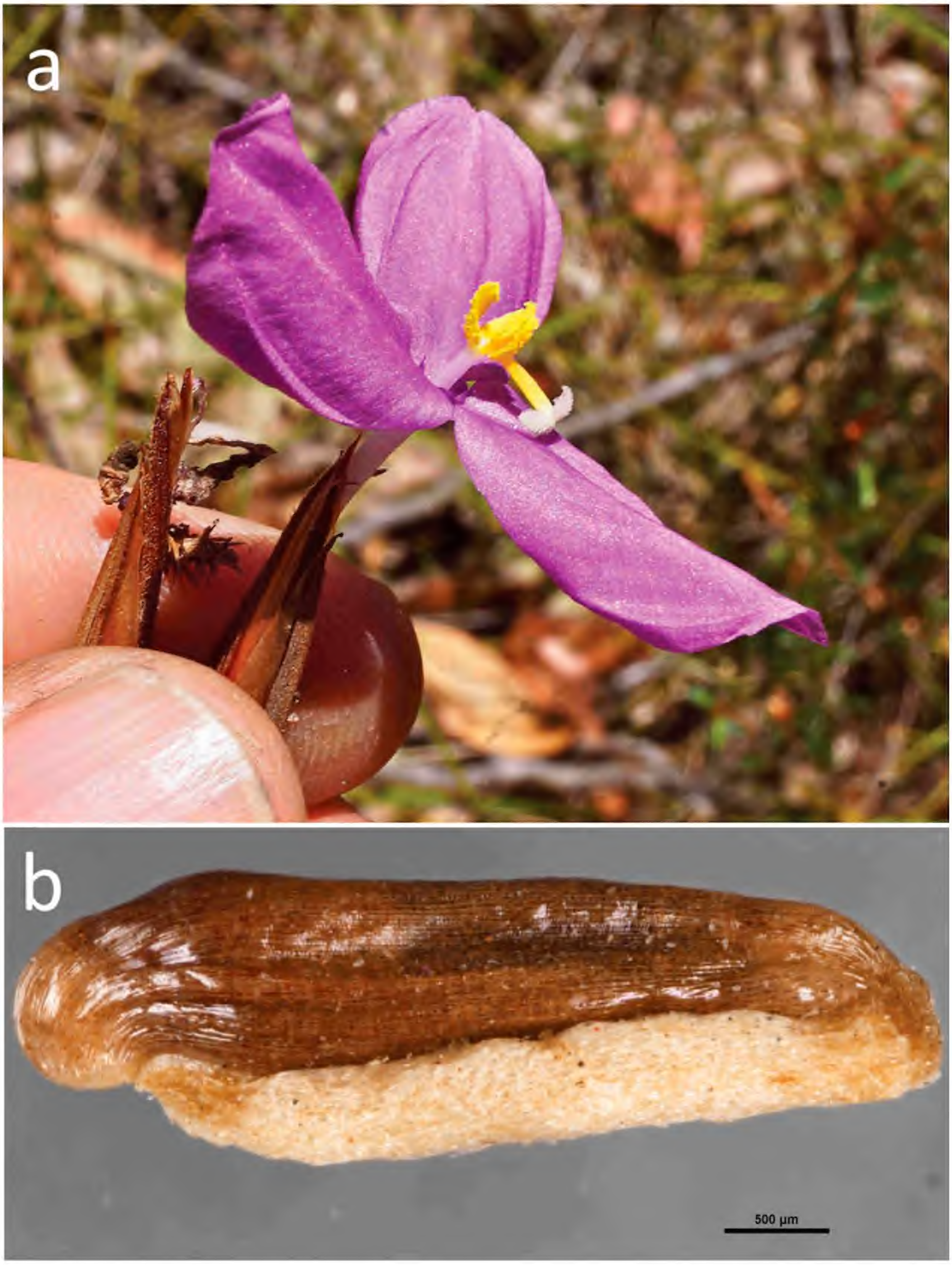

Fig. 2. *Patersonia rosea*: **a.** flower; **b.** seed. Images a = R. Jobson (*R.W. Jobson 4233*); b = J. FitzGerald (*B. Branwhite* s.n., 18 Dec 2022)

Specimens examined: NEW SOUTH WALES [precise localities withheld]: North Coast: Laurieton, Nov 1915, *J.L. Boorman s.n.* (NSW); Central Coast: Charmhaven, 26 Dec 2022, *D.E. Albrecht 16567 & B. Branwhite* (CANB); Wyee, 26 Dec 2022, *D.E. Albrecht 16568* (CANB); Wyee, 26 Dec 2022, *D.E. Albrecht 16569* (CANB, NSW); Charmhaven, 18 Dec 2022, *B. Branwhite s.n.* (CANB).

Distribution: All populations known to be extant occur in the Charmhaven – Wyee area on the New South Wales central coast (Fig 4). A single specimen from Laurieton, c. 200 km further north, collected by J.L. Boorman over a century ago appears to be *Patersonia rosea*. Further field work in the New South Wales north coast region is required to determine whether the species persists at Laurieton and whether it occurs between there and the Charmhaven – Wyee area.

Conservation status: None of the four extant populations currently known in the Charmhaven – Wyee area occur within a conservation reserve, although the species may be present within the nearby Lake Macquarie and Munmorah State Conservation Areas, and Colongra Swamp Nature Reserve. All known populations are small and the total number of plants of the species observed in the field to date is in the low hundreds. Given the extent of potential habitat, the species may be more abundant in the Charmhaven – Wyee area; however, survey is difficult due to private land tenure. The 1915 collection from Laurieton indicates the species may have a more extensive distribution than known populations would suggest, and wider searches are encouraged.

Some populations are currently under imminent threat from development. There is an urgent need to undertake further searches in suitable habitat to gain a more comprehensive understanding of distribution, abundance and threats. The current level of knowledge of the species precludes a confident assessment of conservation status and therefore it is best treated as data deficient. In addition to land clearing, the root rot fungus, *Phytophthora cinnamomi* is another potential threat as *Patersonia rosea* occurs in a habitat that is susceptible to this pathogen. Field observations of the susceptibility of *Patersonia* species to *P. cinnamomi* are currently conflicting (McDougall 2006), and experiments exploring the susceptibility of this species are required.

Habitat: Populations in the Charmhaven – Wyee area occur in dense sedgeland with an open stratum of emergent sclerophyllous shrubs (Fig. 3). These sedge-dominated patches occur within a matrix of open forest/woodland dominated by *Eucalyptus haemastoma* and/or *Angophora inopina* with a heathy understorey. Soils are grey sandy loam, over a poorly drained yellowish subsoil. Species commonly associated with *Patersonia rosea* include *Actinotus minor*, *Angophora inopina*, *Baeckea diosmifolia*, *Banksia oblongifolia*, *Blandfordia grandiflora*, *Comesperma ericinum*, *Cyathochaeta diandra*, *Epacris pulchella*, *Goodenia stelligera*, *Lambertia formosa*, *Lepyrodia scariosa*, *Pimelea linifolia*, *Ptilothrix deusta* and *Xanthorrhoea fulva*. *Patersonia sericea* commonly occurs with *P. rosea*, and *P. fragilis* and *P. glabrata* sometimes also occur in vicinity. At one location *Patersonia rosea* occurs in a power line easement where the vegetation is periodically slashed. These habitats are extensive on the coastal plains of the central coast between Lake Macquarie and Wyong (c. 7800 ha; see Bell and Driscoll 2016, Bell 2019), although they are largely in private ownership with few dedicated conservation reserves. Significant or threatened plant taxa occurring in such habitats include *Acacia bynoeana, Angophora inopina, Cryptostylis hunteriana, Genoplesium branwhiteorum, Genoplesium insignis, Grevillea parviflora* var. *parviflora, Hibbertia stichodonta,* and *Tetratheca juncea* (Bell 2001, 2004; Jones 2001; Toelken 2013; Renner *et al.* 2022; Branwhite pers. obs.).

Phenology: Flowering plants have been noted in December and January, though observations are limited.

Etymology: The specific epithet refers to the colour of the tepals when flowers are open, which is pink in all plants observed to date.

Affinities: Based on the molecular phylogeny of species occurring in eastern Australia, *Patersonia rosea* is sister to *P. glabrata*. (Fig. 5). Seed morphology appears to correlate with molecular data as both species have a linear aril on one side of the seed for virtually the whole length of the seed (Fig. 2b). *Patersonia rosea* resembles *P. glabrata* but is readily distinguished by the leaves being all basal (cf. cauline in *P. glabrata*) and the flowering stems being pubescent above the leaves (cf. glabrous in *P. glabrata*). Additional characters, including tepal colour (open flowers pink in *P. rosea*, cf. violet in *P. glabrata*) and seed aril morphology (lacking a more prominent cap-like part at one end of seed in *P. rosea*, cf. with a more prominent cap-like part at one end of seed in *P. glabrata*) may also separate these two species but the reliability of these features requires further checking.

Fig. 3. Typical habitat of *Patersonia rosea*. Image = D. Albrecht (*D.E. Albrecht 16567 & B. Branwhite*)

Patersonia rosea has also been confused with *P. sericea* as both species have hairy leaves, flowering stems and spathes, at least in part when young. However, *P. sericea* differs from *P. rosea* in having dark brown to blackish spathes (cf. greyish-brown to mid-brown in *P. rosea*) and seeds that are distinctly longitudinally ridged, lack an aril and have a prominent pit at one end (cf. finely and closely longitudinally striate, arillate and lacking a pit at one end in *P. rosea*). Tepal colour (open flowers violet to purple in *P. sericea*, cf. pink in *P. rosea*) may also separate these two species but the reliability of this feature requires confirmation.

Notes: Plants occasionally produce very short flowering stems intermixed with the typical longer ones. There is a tendency for the outermost spathes of short-staked inflorescences to be less hairy. All plants of *P. rosea* seen in the field with open flowers have pink rather that violet or purple tepals. Further checking is required to gauge the consistency of this feature.

The known populations of *Patersonia rosea* occur in habitat containing *P. sericea*, *P. fragilis* and/or *P. glabrata*. These co-occurrences presented the possibility that *P. rosea* may be of hybrid origin with parentage involving two of the latter taxa. To determine whether this was the case, our sequencing effort attempted to compare the maternally inherited plastid marker phylogeny to a paternally inherited nuclear phylogeny with discordance of phylogenetic affiliation between the phylogenies potentially indicating recent hybridization (Jobson & Davies-Colley 2020). Although our nuclear marker sequencing effort was not successful, the maternal tree shows strong genetic divergence between *P. rosea* and its sister species *P. glabrata* (separated by 43 synapomorphies; Fig. 5). In addition, we found that all five accessions of *P. rosea* share indels of 4, 6, 7, 14 and 17 bps long; each of these is not present in any other sampled sequence (data not shown). The possibility that genetic divergence of this magnitude arose between ancestral maternal parent and its hybrid progeny is very unlikely. In addition, the 1915 Laurieton collection c. 220 km NE of the Charmhaven–Wyee sites provides evidence against a localised hybridization event and instead suggests a broader pre-development distribution across the central to lower north coast region (Fig. 4).

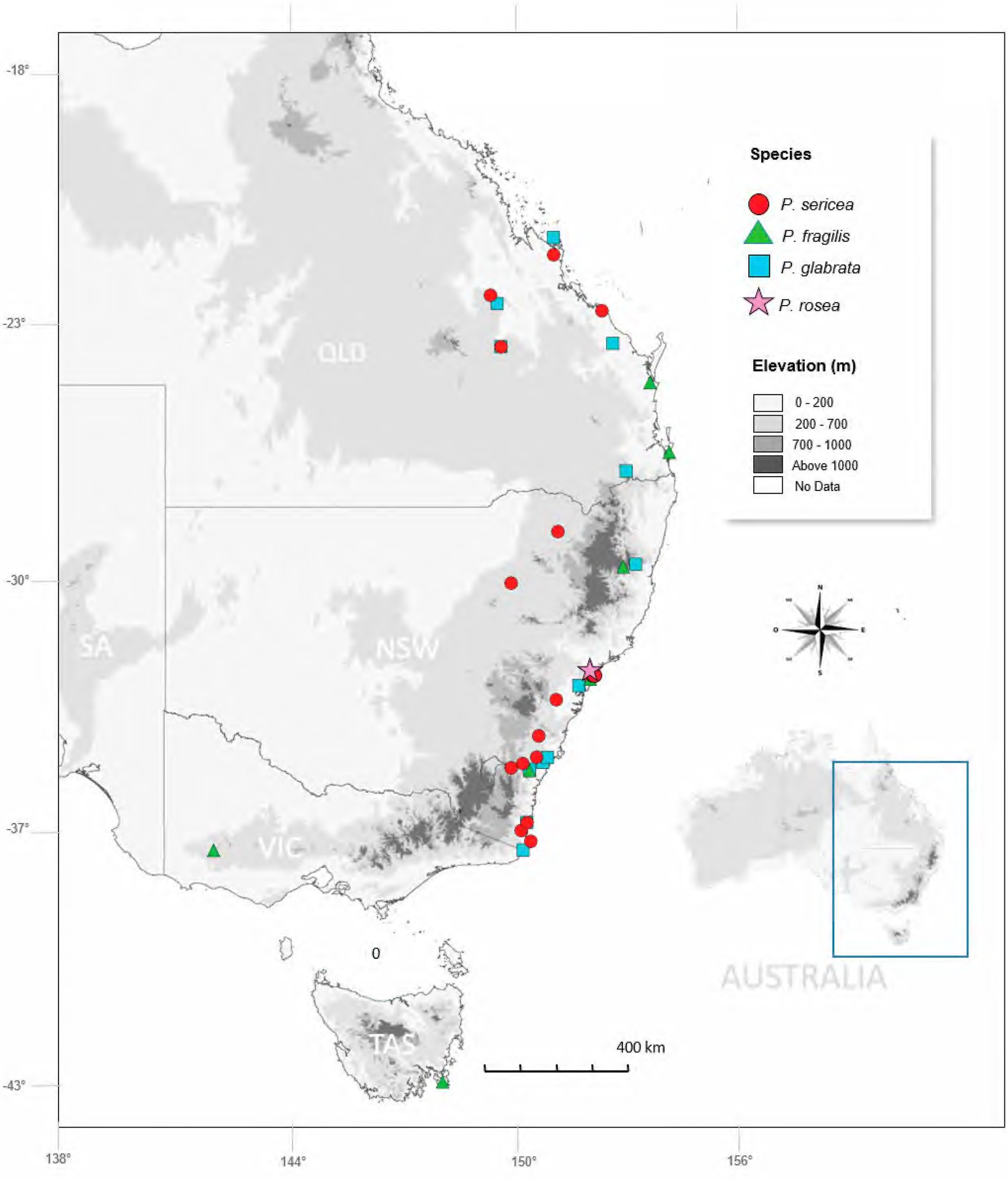

Fig. 4. Australia showing sites of *Patersonia* accessions used in the molecular phylogeny; *P. rosea* (pink star), *P. fragilis* (green triangle), *P. glabrata* (blue square), and *P. sericea* s.l. (red circle). *Patersonia macrantha* (NT) and *P. occidentalis* (SW WA) not shown.

Fig. 5. The 50% majority-rule consensus tree of the Bayesian inference analysis from the combined three cpDNA dataset across the genus *Patersonia* and two outgroup taxa. Recognised species are shown with bars. Outgroup is a collapsed branch (not shown). Branch lengths represent substitution rate; scale bar: 0.03. Posterior probability of strong support is shown above branches (1–0.95), weak support shown where relevant. Unsupported branches not indicated.

Key to the species of *Patersonia* in New South Wales

(Seed measurements exclude aril, if present)

1a. Leaves, flowering stems and spathes glabrous; seeds compressed-ovoid, black, smooth, 2–2.5 mm long with a prominent white aril confined to one end..... ***Patersonia fragilis***

1b. Leaves, flowering stems or spathes at least party hairy when young, sometimes glabrescent with age; seeds cylindrical, cylindrical-fusiform to narrowly ovoid, brown, sometimes with a waxy bloom, finely and closely longitudinally striate to ridged, mostly 2.5–6 mm long, aril lacking or if present then linear and on one side of the seed for virtually the whole length of the seed, with or without a larger cap-like part at one end..... **2**

2a. Leaves cauline; flowering stems (above leaves) glabrous; seeds arillate..... ***Patersonia glabrata***

2b. Leaves all basal; flowering stems (above leaves) pubescent, at least partly; seeds with or without an aril..... **3**

3a Spathes greyish-brown to mid-brown; seeds arillate, lacking a pit at one end ..... ***Patersonia rosea***

3b. Spathes dark brown to blackish; seeds lacking an aril, with a prominent pit at one end ..... ***Patersonia sericea* s.lat.***

* Further study of the infraspecific variation within *Patersonia sericea* is required, which is beyond the scope of this study.

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The family Calymperaceae (Bryophyta) in Australia. Part 5: The genus *Syrrhopodon*

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Abstract

Twenty species of the moss genus *Syrrhopodon* Sw. ex F.Weber are known from Australia. Each species is described and illustrated in detail, and a key to species and distribution maps are provided.

Introduction

Twenty species of *Syrrhopodon* have been reported from Australia (Reese and Stone 2012), making it the most diverse genus of Calymperaceae on the continent. Two nomenclatural changes are accepted in this updated treatment of *Syrrhopodon* since Reese and Stone (2012):

- *Syrrhopodon katemensis* (Zanten) L.T.Ellis replaces *S. prolifer* var. *mossmanensis* W.D.Reese, now considered as a synonym *fide* Ellis (2003). Distinctive features of *S. katemensis* include the smooth costa and chlorophyllose lamina composed of small, densely papillose cells.
- *Syrrhopodon semperi* Müll.Hal., is added to the Australian flora.

SYRRHOPODON Schwägr., *Spec. Musc. Suppl.* 2(2): 110 (1824).

Type species: *Syrrhopodon gardneri* (Hook.) Schwägr., designated by Britton (1989).

Plants solitary or gregarious, forming tufts or low patches. Stems erect or inclined, simple or branched, thin, dark, central strand absent. Leaves variable, usually narrow, with broader erect sheathing bases and erect to patent limbs; margins usually bordered by elongate hyaline cells, or border lacking; margins mostly pluristratose if border lacking. Costa smooth or papillose, in section with a row of guide cells and typically well-developed adaxial and abaxial stereid bands; reaching leaf apex or nearly so, commonly developing clusters of fusiform, multicellular gemmae at the tips. Chlorophyllose lamina typically unistratose, of ± isodiametric cells which may be smooth, mammillose or pluripapillose. Leaf base composed mainly of hyaline cells (the hyaline

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lamina) of variable extent, usually sharply delimited from chlorophyllose lamina cells and usually bordered by differentiated elongate cells. Gemmae clavate or filamentous, mostly borne at apex of costa; specialised gemma receptacles and highly modified gemmmiferous leaves are rare. Dioicous. Male and female plants similar. Capsules borne on slender seta, urn cylindrical, operculum erect, subulate-rostrate. Peristome, when present, simple, of 16 undivided narrow coarsely papillose teeth. Calyptra relatively narrow, cleft at maturity.

Etymology: Greek *syrrhopos* (close together) + *–odon* from *odous* (tooth), referring to the connivent teeth of the peristome.

Syrrhopodon is a widespread, diverse and almost exclusively tropical and subtropical genus of about 80 to 90 species. Most species are found in low to medium altitude rainforests, growing on bark, but some grow on soil or rock and a few are epiphyllic. *Syrrhopodon* has a broader ecological range than either of the non-leucobryoid genera *Calymperes* or *Mitthyridium*.

In contrast to all other genera of Calymperaceae, which are monophyletic, phylogenetic analyses (Fisher *et al.* 2007, Pereira *et al.* 2019) demonstrate that *Syrrhopodon* is polyphyletic. However, whether this polyphyly affects Australian species is not clear, and we therefore choose to keep all Australian species currently accepted in *Syrrhopodon* in that genus.

The differentiated leaf margin found in many species of Calymperaceae is often useful in separating *Calymperes* from *Syrrhopodon*. In many species of *Calymperes* there is a narrow strip of elongate, often thick-walled hyaline intramarginal cells in the sheathing leaf base. In *Syrrhopodon* the sheathing base is often bordered by elongate cells, but they are never intramarginal.

Syrrhopodon differs primarily in habit from *Mitthyridium*, which has a creeping primary stem and leaves with a uniformly unistratose border. *Syrrhopodon* has an upright habit, and the hyaline border, if present at all, is typically more than one cell thick.

In the following treatment the descriptions are based on studies of a representative sample of collections held in Australian herbaria, supplemented by our own collections. The symbol !d indicates that a high-resolution digital image has been seen via JSTOR Global Plants 2022 (www.plants.jstor.org). Synonyms cited are of Australian taxa only; for other synonyms, see the literature cited for each species.

Key to the species of *Syrrhopodon* in Australia

1 Margins at leaf shoulders dentate, serrate or ciliate on at least some leaves (usually most) 2

1. Margins at leaf shoulders entire or nearly so 8

2 Leaf margins with delicate cilia from the shoulders almost to the apex ..... *S. ciliatus*

2. Leaf margins toothed or ciliate only at or near shoulders, although limb may be finely dentate by projecting cell ends 3

3 Leaf border lacking elongate hyaline cells 4

3. Leaf border composed entirely or in part of elongate hyaline marginal cells 5

4 Leaves with margins weakly bordered, sharply dentate-serrate at shoulders; hyaline lamina sharply delimited, in about 8–10 rows either side of costa ..... *S. gardneri*

4. Leaves with margins of limb thickened, with strongly developed but largely concealed marginal stereomes, long-ciliate at shoulders; hyaline lamina occupying almost entire sheath, tapering upwards and ending at base of limb at an acute angle ..... *S. perarmatus*

5 Leaves mostly 4–9 mm long with bases usually glossy red-brown, contrasting strongly with limb, hyaline lamina small, mostly eroded ..... *S. croceus*

5. Leaves mostly less than 5 mm long with bases pale to dark green, not red-brown, not constrasting strongly with limb, hyaline lamina conspicuous, intact 6

6 Cells of limb unipapillose on both surfaces, the papillae often tall and conspicuous; leaf shoulders with delicate cilia ..... *S. armatus*

6. Cells of limb with multifid papillae; cilia present or lacking on leaf shoulders 7

7 Plants pale to olive green to brownish; leaves spreading to patent, little altered wet or dry, 2.5–4.0 mm long; costa hispid on both surfaces in limb; hyaline lamina sharply delimited, occupying almost entire leaf sheath, ± scalariform, ending at a narrow acute angle to the costa, penetrating quite high into base of limb, bordered by a narrow band of 3–4 rows of thick-walled elongate cells ..... *S. spiculosus*

7. Plants dark green to brownish green or rusty green; leaves involute and uncinate to curled when dry, straight to slightly incurved when moist, 1.5–2.5 mm long; costa mostly smooth; lamina cells of limb papillose with multifid or coronate papillae, thick-walled, rounded-quadrate; hyaline lamina of relatively few rows of cells, rounded distally or weakly scalariform, bordered marginally by elongate cells of leaf border ..... *S. semperi* (see also *S. trachyphyllus* 20)

8 Hyaline lamina occupying half or more leaf length 9

8. Hyaline lamina occupying less than half leaf length 11

9 Plants growing exclusively on *Platycerium* ferns; leaf limb strongly helically twisted above shoulders when dry, straight when moist ..... *S. platycerii*

9. Plants growing on other substrates; leaf limb straight or variously contorted when dry but not helically twisted 10

10 Leaf margins conspicuously and evenly serrate in upper half; chlorophyllose lamina cells filling the leaf limb, hyaline lamina reaching 2/5–1/2 leaf ..... *S. confertus*

10. Leaf margins entire or toothed at apex only, erect, involute or revolute; chlorophyllose cells confined to apical region of leaf, hyaline lamina filling at least 3/4 of leaf length ..... *S. involutus*

11 Leaf margins lacking elongated hyaline cells 12

11. Leaf margins composed at least in part of elongate hyaline cells 13

12 Leaves monomorphic, narrowly linear-acuminate from a slightly wider sheathing base, 5–12 mm long ..... *S. aristifolius*

12. Leaves dimorphic, broadly lanceolate, sheathing base no wider than the limb, 2.5–4.0 mm long ..... *S. stoneae*

13 Elongate hyaline cells of leaf marginal stereome ± covered by shorter square to rectangular cells; leaves stiffly erect ..... *S. muelleri*

13. Elongate hyaline cells of leaf margins exposed; leaves variously contorted or straight when dry 14

14 Leaf margins distinctly serrate, at least in upper third, margins conspicuously bordered with a pellucid marginal stereome ..... *S. tristichus*

14. Leaf margins entire, or toothed only at extreme apex 15

15 Lamina cells of limb smooth, or mostly unipapillose 16

15. Lamina cells of limb pluripapillose 18

16 Leaves spreading-patent wet or dry, the limb bent outwards and commonly with a half twist; cells of chlorophyllose lamina mostly unipapillose ..... *S. albovaginatus*

16. Leaves erect to erect-appressed when dry; cells of chlorophyllose lamina mostly smooth or unipapillose, the papillae sometimes bifid or trifid 17

17 Cells of chlorophyllose lamina conspicuously spinose-papillose with tall simple or apically divided papillae; gemmae fusiform clavate, adaxial on leaf tips ..... *S. cyrtacanthos*

17. Cells of chlorophyllose lamina smooth or inconspicuously unipapillose with low undivided straight papillae; gemmae filamentous, adaxial at mid leaf ..... *S. parasiticus*

18 Plants growing mostly on the dried base of *Platycerium* ferns; leaf limb helically twisted when dry ..... *S. platycerii*

18. Plants not growing on *Platycerium* ferns; leaf limb straight to variously contorted when dry but not helically twisted 19

19 Leaves erect to erect-spreading wet or dry, not otherwise contorted ..... *S. spiculosus*

19. Leaves variously contorted when dry, not spreading-patent 20

20 Plants dark green to brownish green or rusty green; leaves oblong to ligulate from a slightly broader base, 1.5–2.5 mm long ..... *S. trachyphyllus*

20. Plants pale green to olive green; leaves narrowly lanceolate, 2–5 mm long 21

21 Leaves 2–5 mm long; lamina cells at mid limb about 6–8 μm; cells of limb with low, inconspicuous papillae on both surfaces ..... *S. prolifer*

21. Leaves 1.5–2.0 mm long; lamina cells at mid limb about (6–)8–10(–12) μm; cells of limb with a single tall, stout multifid papilla on both surfaces ..... *S. katemensis*

1. *Syrrhopodon albovaginatus* Schwägr., *Spec. Musc. Suppl.* 2(2): 112, pl. 131 (1824).

Original material: 'Ad ligna in insula Radack [Rawack] moluccensi lectum misit cl. Gaudichaud, Freycineti peregrinatoris socius, per manum cl. Gay.'

Type: Indonesia: Maluku Islands, *C.Gaudichaud-Beaupré s.n., s.d.* (before 1824); lectotype: (designated by Ellis 2011) G00042877, not seen; isolectotypes: G00048221, G00124234, BM000675307, BM000675278, BM000675279, BM000675281, BM000675282, BM000675291, BM000675296 (all designated by Ellis 2011, not seen), PC0100823!d, PC0100824!d.

Illustrations: Fig. 1. Also Ellis and Tan (1999: 30).

Description: Plants small, to 2 cm tall but mostly shorter, occasionally taller; pale glaucous green, forming low mats or tufts. Stems erect, mostly simple, slender; rhizoids red. Leaves ± patent wet or dry, from an erect colourless sheathing base 2.0–4.0 mm long, narrowed abruptly to a linear-ligulate limb, the limb bent outwards and commonly with a half twist; leaf blade typically less than twice the length of the sheath, ± parallel-sided, narrowed to an acute to subacute, serrate apex; leaf surface on the limb appearing hispid with conically projecting cells arranged in ± obliquely transverse rows; margins of limb serrate for about half or more down limb from apex; margins distinctly bordered in blade and sheath. Costa ending below leaf tip, denticulate on both adaxial and abaxial surfaces. Lamina cells variable in size, rounded-quadrate, thick-walled, smooth or with conical projecting surfaces. Hyaline lamina occupying whole of leaf sheath, sharply delimited, scalariform, obliquely narrowing to costa above; lamina narrowly decurrent down sides of the hyaline lamina. Sporophytes apparently uncommon. Calyptra to 2 mm long. Seta 6–12 mm long, reddish-brown; capsule about 1.5 mm long, 0.5 mm wide; operculum slenderly long-rostrate, about 1.0 mm long; peristome teeth yellow, fragile, slenderly pointed, about 120 μm long, papillose, with faint transverse bars. Spores 9–12 μm in diameter, finely granular.

Etymology: Latin *albovaginatus* (with a white sheath), referring to the pale sheathing base of the leaves when dry.

Distribution: North-eastern Queensland, between Iron Range and Bellenden Ker Range (Fig. 21.1). Also known from south-eastern Asia (Thailand), Malesia, North Borneo, Philippines, Papua New Guinea, Oceania (New Caledonia).

Habitat: Rotting logs, stumps, tree roots and bases, and occasionally on humus, in lowland forest from near sea level to about 250 m a.s.l. in Australia, to somewhat higher elevations elsewhere.

Recognition: *Syrrhopodon albovaginatus* seems to be rare in Australia. Plants of *S. spiculosus* and *S. albovaginatus* can appear similar because the leaves of both species are spreading-patent when wet or dry. The margins of the leaf shoulders of *S. albovaginatus* are entire, while in *S. spiculosus* they are usually toothed-spiculose but may also be smooth. The chlorophyllose lamina of *S. spiculosus* lacks the striking obliquely transverse abaxial rows of tooth-like cells that are characteristic of *S. albovaginatus*.

Selected specimens seen: Queensland: Cape Tribulation National Park, about 2 km north of Cape Tribulation, along road to Bloomfield, *W.D.Reese 17365*, 6 June 1989, MEL 2333049A.

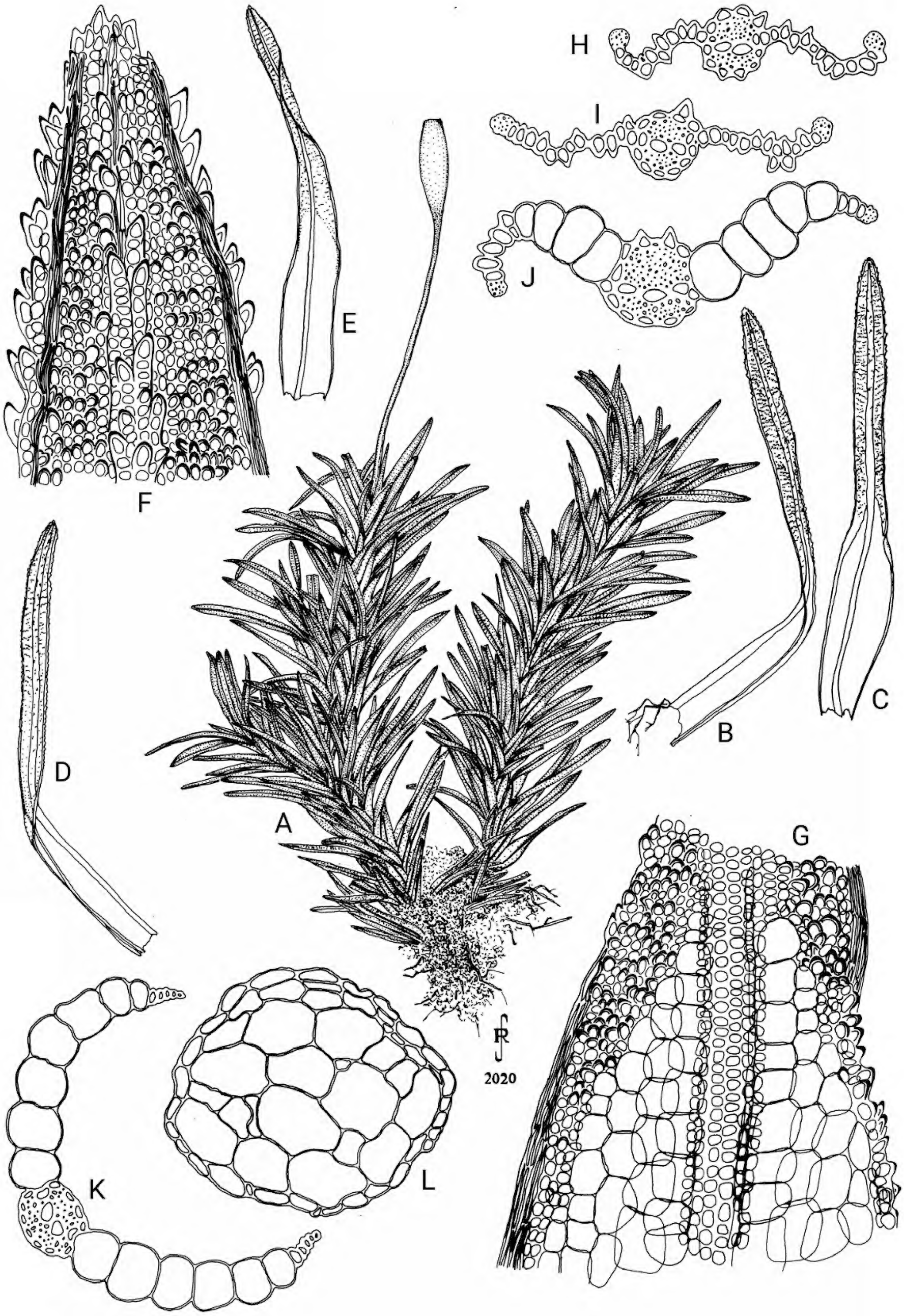


Fig. 1. *Syrrhopodon albovaginatus* Schwägr. **A:** Habit of fertile plant, drawn moist. **B–E:** Stem leaves. **F:** Cells of leaf apex, abaxial view. **G:** Cells of distal end of sheathing leaf base. **H, I:** Sections of leaf limb. **J, K:** Sections of sheathing base of leaf. **L:** Stem section. Drawn from *W.D.Reese 17365*.

2. *Syrrhopodon aristifolius* Mitt., *J. Linn. Soc., Bot.* 10: 176 (1868).

Original material: 'Hab. Upolu, on trees (1000–2000 ft.). No. 89.'

Type: Samoa, Upolu, *T.Powell 89,* Aug 1864, as *aristifolium*; syntypes: NY01114135!d, NY01114136!d, NY01114137!d, MO406828!d, MICH526423!d. Note: The collection date is taken from the NY and MO specimens.

Illustrations: Fig. 2. Also Ellis and Tan (1999: 31).

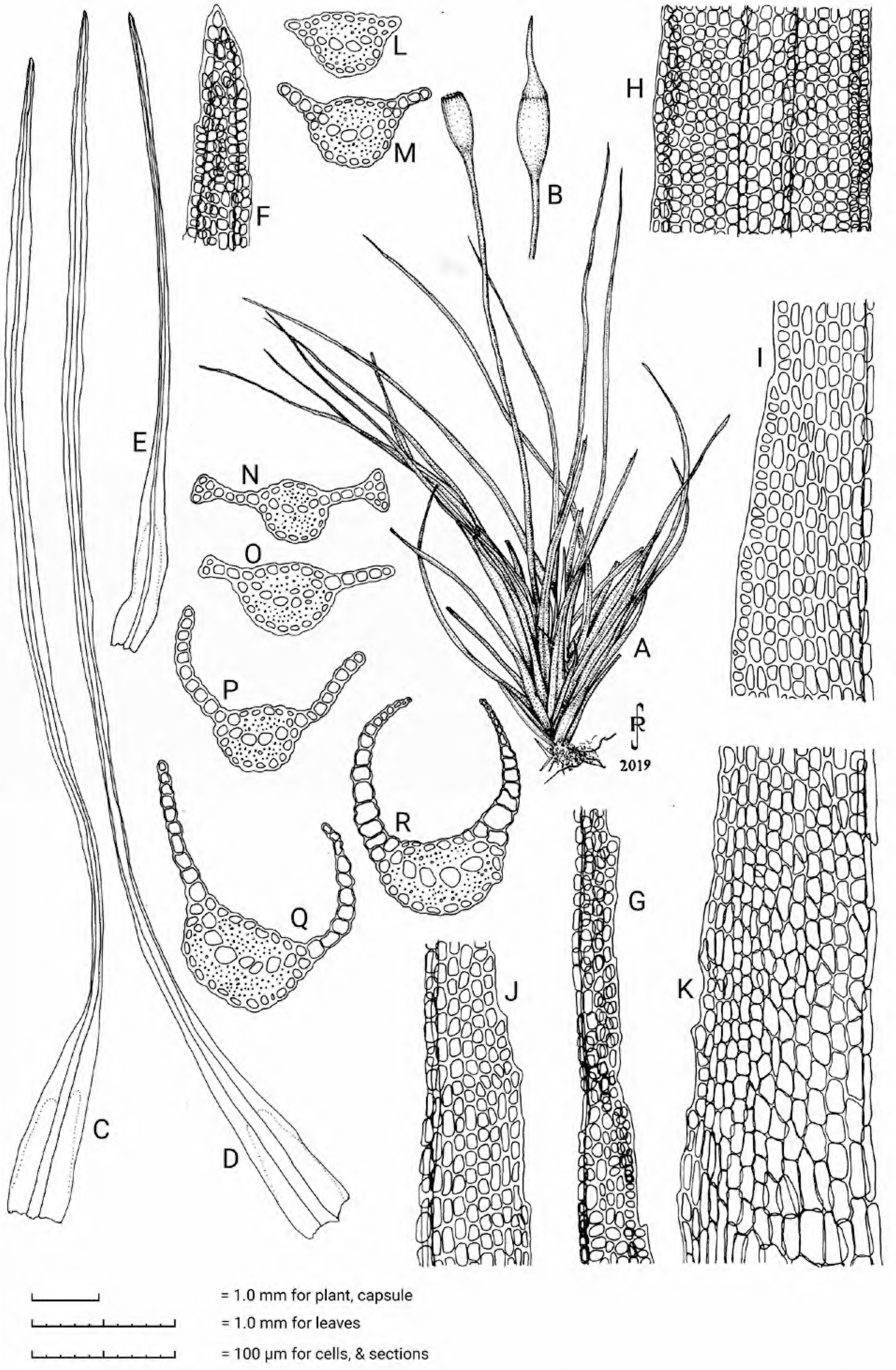


Fig. 2. *Syrrhopodon aristifolius* Mitt. **A:** Habit of fertile plant, drawn moist. **B:** Detail of capsule and operculum. **C–E:** Stem leaves. **F:** Cells of leaf apex. **G:** Marginal cells of upper limb. **H:** Cells of mid chlorophyllose lamina, abaxial view, with bistratose margin. **I:** Cells of base of limb. **J:** Cells of lower mid limb. **K:** Cells of basal chlorophyllose lamina and distal end of hyaline lamina. **L:** Section of leaf apex. **M–O:** Sections of distal end of leaf limb. **P:** Section of lower leaf limb. **Q, R:** Sections of hyaline lamina. Drawn from *A.Cairns B-304.*

Description: Plants small, often ± stemless, occasionally up to 10 mm long and fastigiately branched; growing in low loose wiry tufts or mats, dull green to brownish-green; rhizoids dark red-brown. Leaves glossy, loosely curled-contorted when dry, spreading ascending when moist, 5–12 mm long, sheathing base about 0.3–0.4 mm wide, limb 0.15–0.3 mm wide, linear to acuminate-subulate from a slightly wider sheathing base; leaf margins unistratose below base of limb, ± entire, becoming multistratose in limb and forming a distinct border composed entirely of chlorophyllose cells, marginal stereome lacking; costa strong, smooth, percurrent or excurrent, sometimes gemmiferous, in section biconvex, with 4–6 guide cells, adaxial and abaxial stereid bands, and epidermal layer of lamina-like cells; lamina evanescent in leap tip, typically only 3–7(–9) cells wide in mid limb; lamina cells rounded quadrate to short rectangular, 6–12 μm wide, ± convex on both surfaces, smooth. Hyaline lamina relatively small, often indistinct, eroded in older leaves, typically obliquely truncated distally but not sharply differentiated from chlorophyllose lamina. Gemmae pale, inconspicuous, fusiform-cylindrical, borne adaxially near leaf tips. Sporophytes apparently rare in Australian material.

Etymology: Latin *arista* (awn) + *folius* (leaf), referring to the long, tapering, awn-like leaf apex.

Distribution: North-eastern Queensland, from the Windsor Tableland to the Paluma Range, north-west of Townsville (Fig. 21.2). Also known from tropical Asia, Malesia, Philippines, Papua New Guinea, Western Samoa, and reported from Socotra, an island south-east of Yemen.

Habitat: On tree trunks in notophyll/microphyll vine forest to about 1200 m asl.

Recognition: *Syrrhopodon aristifolius* is easily recognised by its primarily stemless habit, the often petiolate leaves where the limb is somewhat constricted above the shoulder region before expanding into the upper limb, small and inconspicuous and obliquely truncate hyaline lamina, smooth lamina cells and lack of hyaline marginal cells. *Syrrhopodon muelleri* is also ± stemless, but there the leaf margins are bordered by elongate hyaline cells and the small hyaline lamina is clearly defined and persistent, the leaves are pale yellowish-green and often twisted. Reese and Tan (1983) reviewed the species of Calymperaceae with leaves having petiole-like constrictions between the sheathing leaf base and the proximal end of the green upper lamina.

Selected specimens seen: Queensland: Paluma Dam Road, Paluma, forest adjacent to Birthday Creek. *A.Cairns B-304*, 5 October 2004, BRI AQ0649295; H-Road, Cardstone, *I.G.Stone 25773*, 10 July 1991, MEL 2331846A.

3. *Syrrhopodon armatus* Mitt., *J. Linn. Soc., Bot.* 7: 151 (1863).

Original material: 'Hab. Bagroo River and banks of the Nunn [Noun River], on dead bark, Mann.'

Type: (syntypes) 1 – Sierra Leone: Bagru River, *G.Mann s.n.* 1861; 2 – Cameroon: banks of the Noun River, *G.Mann s.n.* 1861; 1 – BM000677014!d, BM000677015!d, PC0098980!d, SB179979!d, PC0106434!d, 2 – NY00910808!d, NY00910809!d, NY00910810!d.

Notes: As far as we know, a lectotype has not been selected from the syntypes cited. The collecting date for syntype 1 is taken from BM000677015 and SB179979. Mann collected in Sierra Leone before travelling to Cameroon to collect (Mann 1861).

Australian synonyms: *Syrrhopodon fimbriatus* Müll.Hal., *Linnaea* 37: 151 (1872), *non S. fimbriatus* Mitt., *J. Linn. Soc., Bot.* 12: 122 (1869). = *Syrrhopodon fimbriatulus* Müll.Hal., *J. Mus. Godeffroy* 3(6): 52 (1874), (in footnote), *fide* Reese and Bartlett (1982). **Original material:** 'Patria. Brisbane River Novae Holl. or. inter Hypnum austro-pusillum vigens: Amalie Dietrich 1864.' **Type:** Australia, Queensland, Brisbane River, *A.Dietrich s.n.*, 1864, holotype B (destroyed), isotype not seen.

Syrrhopodon cairnensis Broth. & Watts, *Proc. Linn. Soc. New South Wales* 43: 551 (1918), *fide* Reese and Stone (1995). **Original material:** 'Cairns district, Babinda, on tree-trunks, n. 313a (leg. Watts, July, 1913).' **Type:** Australia, Queensland, Babinda, *W.Watts 313a*, July 1913, holotype ?HBR not seen, isotype NSW752806!

Illustrations: Fig. 3. Also Reese and Lin (1991: 354), Ellis and Tan (1999: 35).

Description: Plants small, pale green, to 10 mm tall, gregarious, forming thin to dense cushions and turfs. Stems erect, forked, often repeatedly; rhizoids red. Leaves tightly curled-contorted and involute when dry, ± plane and ascending when moist, apex broadly acute to bluntly rounded, linear-ligulate from a slightly broader base, 2–3(-4) mm long. Costa often conspicuously spinose-papillose adaxially and abaxially, ending in or below the apex. Leaf margins erect-involute, bordered with 2–3 rows of narrow elongate hyaline cells but border sometimes weak and incomplete in upper part of limb; border at leaf shoulders usually with hyaline ± delicate cilia; cells of upper chlorophyllose lamina rounded-quadrate, thick-walled, stoutly unipapillose on both surfaces, the papillae often tall and conspicuous. Hyaline lamina narrow, acute or sometimes narrowly rounded distally. Gemmae small, cylindrical-clavate, in low dense pads on adaxial surface of leaf tips. Sporophytes uncommon in Australian material. Calyptra about 1.5 mm long. Seta yellow, short, about

4.0 mm long. Capsule urn about 1.0 mm long; operculum 0.8 mm, slenderly rostrate. Peristome teeth orange, slender pointed, irregularly segmented, papillose on both surfaces, to about 120 µm long. Spores 12–15 µm in diameter, yellowish, finely granular.

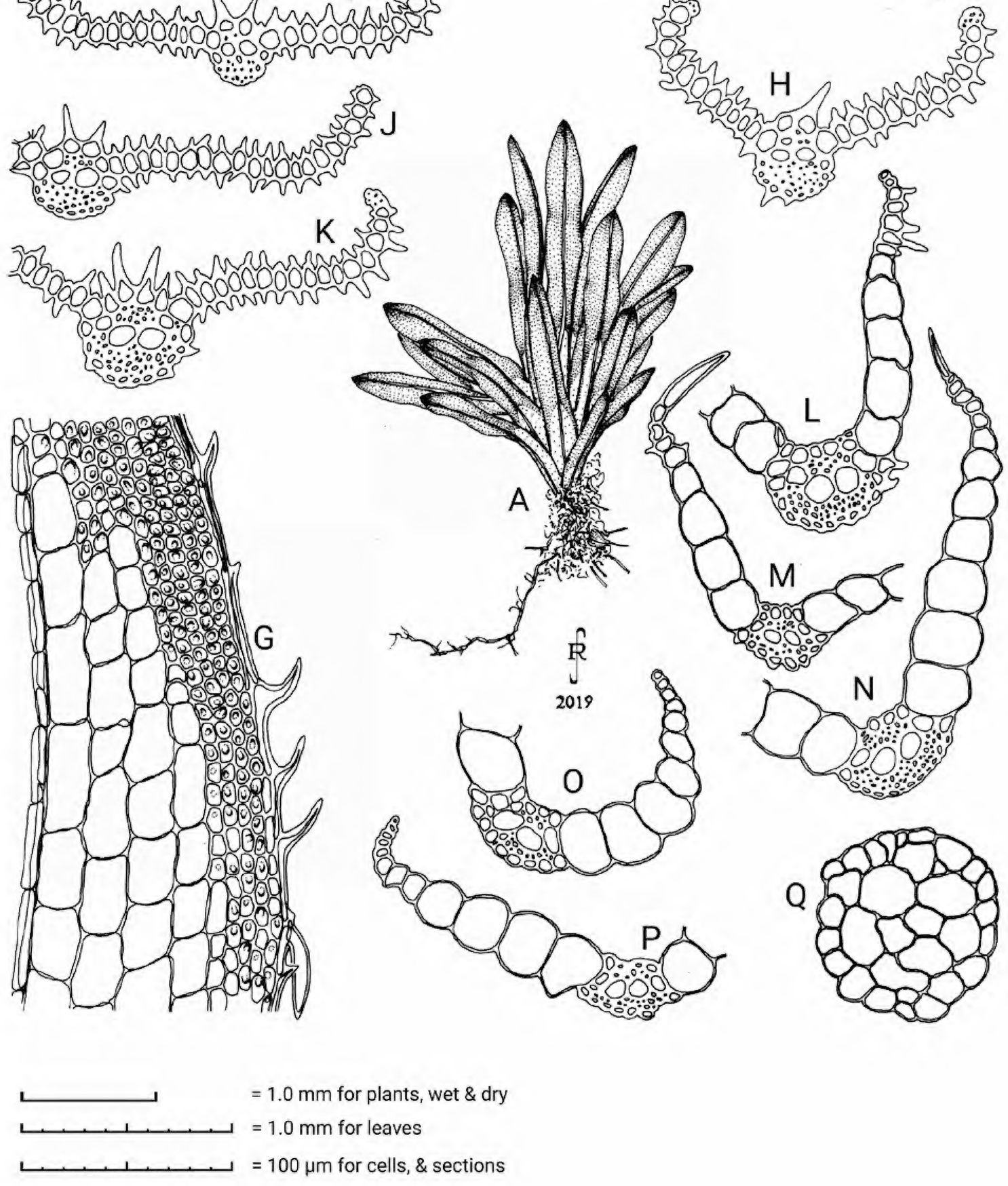


Fig. 3. *Syrrhopodon armatus* Mitt. **A:** Habit of plant, drawn moist. **B, C:** Habit of plants, drawn dry. **D, E:** Stem leaves. **F:** Cells of leaf apex, abaxial view. **G:** Cells of leaf shoulder region. **H–K:** Sections of leaf limb. **L–N:** Sections of leaf shoulder and upper part of sheathing base. **O, P:** Sections of lower part of sheathing leaf base. **Q:** Stem section. Drawn from *W.D.Reese 17370*.

Etymology: Latin *armatus* (armed), referring to the strongly ciliate lower leaf margins.

Distribution: Widespread from northern Northern Territory to eastern Queensland and New South Wales as far south as Batemans Bay (Fig. 21.3). Elsewhere, widely distributed in the palaeotropics, Central and West Africa, Madagascar, China, Malesia, Philippines, Hawaii, and New Zealand (North Island, Kermadec Islands).

Habitat: Tree trunks, rotted wood, logs, stumps, soil and rocks, mostly at low elevations but up to about 1000 m a.s.l.

Recognition: *Syrrhopodon armatus* is the most common and widespread *Syrrhopodon* in Australia. It is easily recognised by its pale green, almost glaucous appearance, the uncinate-curled leaves when dry, conspicuous cilia on the leaf shoulders, often spinose costa, and unipapillose cells. The spinose papillae of the leaf cells impart to the leaves a roughened or hispid appearance when dry.

Selected specimens seen: Queensland: Cape Tribulation National Park, about 2–4 km north of Cape Tribulation along road to Bloomfield. *W.D.Reese 17370*, 6 June 1989, MEL 2333050A; Tara Vale Road, Paluma, *A.Cairns B-84*, 28 Aug 1999, BRI AQ0649296. New South Wales: Three Mile Scrub, Richmond River, Watts NSW5824, 10 Oct 1902, NSW 752765.

4. *Syrrhopodon ciliatus* (Hook.) Schwägr., *Spec. Musc. Suppl.* 2(2): 114, pl. 130 (1823).

Basionym: *Weissia ciliata* Hook., *Musci Exotici* 2: 171 (1820).

Original material: 'Hab. Ex insula Ternate accepit D. Dicksonus.'

Type: Indonesia, Ternate, *D.Dickson s.n.,* 1813; syntypes: BM000675391!d, ?BM000675396!d, ?BM000675398!d, BM000675395!d, E00011913!d, E00007628!d, E00261221!d.

Note: The collection date is taken from BM000675391, which is annotated as the holotype although there is no evidence that it is so. BM000675396 is ex herb. Wilson, annotated 'T. 16.a' and 'Indian Ocean'.

Illustrations: Fig. 4. Also Ellis and Tan (1999: 30).

Description: Plants to 2 cm tall, rarely more than 1.5 cm, yellowish green, forming loose to dense tufts or turfs. Stems erect, simple or forked; rhizoids red. Leaves strongly dimorphic (gemmiferous leaves sometimes rare); vegetative leaves spreading-recurved when wet or dry, ligulate to linear or oblong, 2–3 mm long, apex broadly acute to rounded-obtuse, often inconspicuously mucronate; margins bordered, the border narrow, pellucid, usually ending well below leaf apex, bearing long delicate unicellular cilia from the shoulders almost to the apex, cilia 150–350 μm long; gemmiferous leaves highly modified, stiff erect, ± tubular by inrolled margins, cilia absent. Costa narrow, smooth except for near apex where densely spiculose, with scattered long delicate cilia abaxially; gemmae fusiform, borne in dense terminal clusters on costa. Costa rounded in section, with 2(-4) guide cells, adaxial and abaxial stereid bands and an epidermal layer of thick-walled pellucid cells. Cells of chlorophyllose lamina smooth, ± quadrate, 8–12 μm wide. Hyaline lamina sharply delimited, occupying most of leaf sheath, scalariform, chlorophyllose cells decurrent down margins of sheath. Sporophytes not seen in Australian material.

Etymology: Latin *ciliatus* (with eyelashes), referring to the cilia on the margins of the leaf lamina and on the costa.

Distribution: In Australia known only from Litchfield National Park in the Northern Territory (Fig. 21.4). Elsewhere known from tropical Asia, Malesia, North Borneo, Philippines, Papua New Guinea, Oceania.

Habitat: Grows in monsoon vine forests, on the ground, on tree roots, and in shaded escarpments on rock wall seepages.

Recognition: *S. ciliatus* is distinguished from other Australian species by its smooth cells, conspicuously ciliate leaves, and the highly modified, more or less tubular, gemmiferous leaves. Although seemingly rare in tropical monsoon areas of northern Australia, it is common and often abundant elsewhere in its range.

Selected specimens seen: Northern Territory: Curtain Falls, 'Pethericks Rainforest', 38 km SE of Bachelor, *H.Streimann 48185*, 03 July 1991, CANB 9108230.

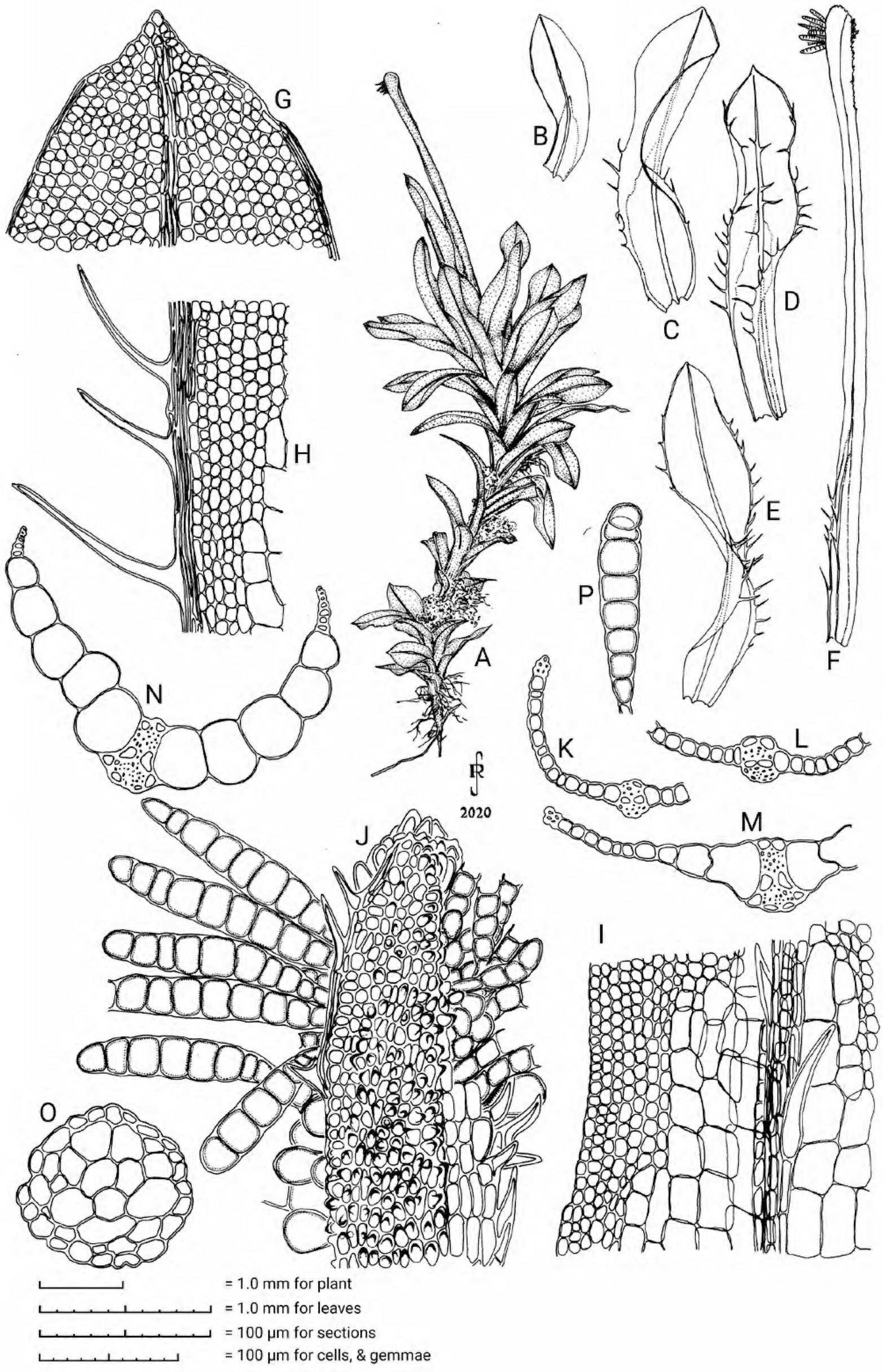


Fig. 4. *Syrrhopodon ciliatus* (Hook.) Schwägr. **A:** Habit of gemmiferous plant, drawn moist. **B–E:** Stem leaves. **F:** Gemmiferous leaf. **G:** Cells from leaf apex. **H:** Marginal cells of leaf sheath. **I:** Cells of hyaline lamina. **J:** Detail of apex of gemmiferous leaf, abaxial view. **K, L:** Sections of leaf limb. **M:** Section of leaf sheath at distal end of hyaline lamina. **N:** Section of leaf sheath. **O:** Stem section. **P:** Gemma. Drawn from *H.Streimann 48185*.

5. *Syrrhopodon confertus* Sande Lac., *Verh. Kon. Akad. Wetensch., Afd. Natuurk.* 13: 4, 2c (1872).

Original material: 'Hab. Sumatra, Korthals; Banca ad arbores inter Klappa et Tjang-tara, Kurz.

Type: Lectotype (first step), designated by Mohamed and Reese (1985): Indonesia: Banca, *S.Kurz 68,* 4 Aug 1858: MO-406869, BC (A:5912376), L0060699, L0060700, *fide* Touw (2013), not seen (second step required to select a single specimen).

Note: The collecting number and date for the lectotype are taken from Touw (2013), who noted that Mohamed and Reese (1985) lectotypified *S. confertus* by the Kurz collection, but did not specify a herbarium specimen.

Illustrations: Figure 5. Also Ellis (1985: 13), Ellis and Tan (1999: 33).

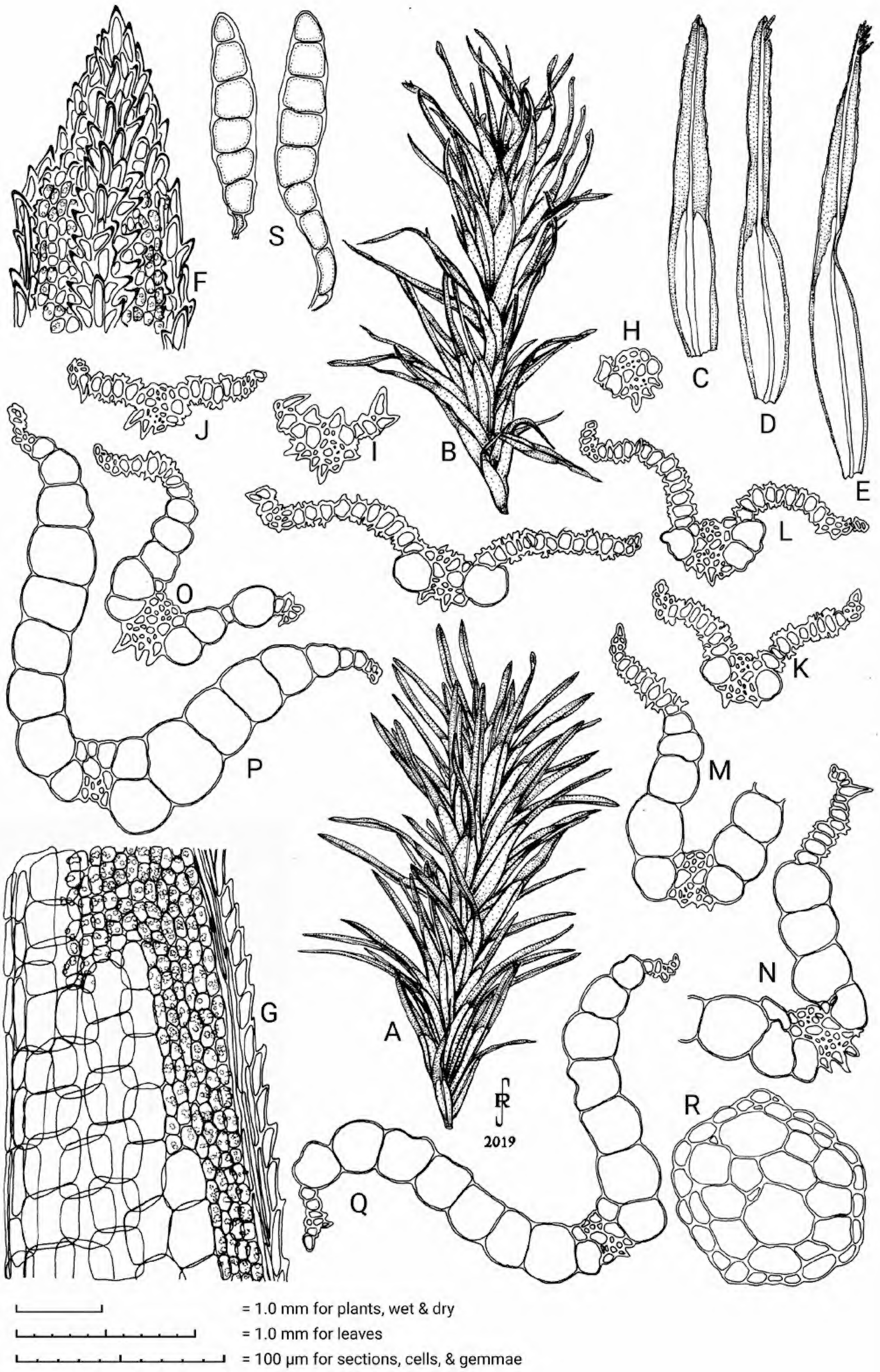


Fig. 5. *Syrrhopodon confertus* Sande Lac. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C:** Stem leaf. **D, E:** Leaves bearing gemmae. **F:** Cells of leaf apex, abaxial view. **G:** Cells of upper hyaline lamina. **H–J:** Sections of leaf apex and upper part of limb. **K–N:** Sections of sheathing leaf base. **P, Q:** Sections of sheathing base from near leaf insertion. **R:** Stem section. **S:** Gemmae. Drawn from *A.J.Franks AJF1412004A*.

Description: Plants small, pale green to yellowish, in soft compact glossy tufts or turfs, up to 2 cm tall. Stems erect; rhizoids red. Leaves monomorphic, scarcely altered wet or dry, not contorted, 2–3 mm long, narrowly acuminate from a slightly broader base 0.25–0.3 mm wide, limb 0.15–0.3 mm wide in mid leaf, spreading-ascending; margins of limb with a sharply defined border with several layers of elongate hyaline stereid-like cells; denticulate to strongly serrate by projecting cells, the teeth close together, occasionally remote, single or occasionally double near leaf tip; cells of limb papillose, the papillae mostly multifid, cells of chlorophyllose lamina filling the leaf limb, then decurrent down the margins of the hyaline lamina; hyaline lamina conspicuous, reaching 2/5–1/2 leaf, scalariform; costa narrow, ending at or just below the apex, in section with 2–3 guide cells, small adaxial and abaxial stereid bands, without a differentiated epidermal layer but epidermal cells conical spiculose-mammillose, particularly abaxially, to near leaf base. Gemmae scarce, short-fusiform, borne adaxially along costa at leaf tip. Sporophytes not known in Australian material.

Etymology: Latin *confertus* (crowded, thick), referring to densely crowded leaves.

Distribution: North-eastern Queensland from Cape Tribulation to Tully (Fig. 21.5). Also in tropical Asia from Sri Lanka, Thailand, Malesia to Papua New Guinea, and west into the Pacific islands.

Habitat: Usually in wet complex mesophyll vine forests, on tree trunks, stumps, logs, boulders and tree ferns, mostly at low elevations but ranging up to about 1000 m a.s.l.

Recognition: *Syrrhopodon confertus* is easily recognised by its compact glossy tufted habit and the small leaves having conspicuous regular marginal serrations. Similar in appearance and habit to *S. involutus*, but there the leaf margins are entire. *Syrrhopodon confertus* was formerly recognised in Australia as *S. amoenus* Broth., a synonymous species described from Papua New Guinea with less markedly papillose cells and almost entire leaf margins. Eddy (1990) considered this difference somewhat 'arbitrary'. Tixier (1978) noted that the '*amoenus*' forms predominated in the southern and eastern parts of Malesia, while the '*confertus*' forms were principally in the northern and western parts, suggesting the possibility of varietal distinction. However, a similar variation occurs in *S. spiculosus* with no suggestion of varietal recognition. Enigmatically, throughout its range, sporophytes have not been seen and gemmae appear to be rarely encountered.

Selected specimens seen: Queensland: Cook District; Golden Hole Reserve, second order tributary of Russell River. *A.J.Franks AJF1412004A*, 04 December 2014 (BRI AQ0910141).

6. *Syrrhopodon croceus* Mitt., *J. Proc. Linn. Soc., Bot. Suppl.* 1: 41 (1859).

Original material: 'Hab. Singapore, Wallich! Etiam in insula Labuan, Motley!'

Type: (syntypes) (1) Singapore: s.loc., *N.Wallich s.n., s.d.* (1822–1823); (2) Malaysia, Labuan, *J.Motley 17,* 1849–1853; isosyntypes (1) BM000676813!d, BM000676814!d, BM000676815!d, BM000676816!d, BM000676817!d, (2) PC0100332!d PC0100333!d, NY01127570!d, NY01127571!d, NY01127572!d.

Note: As far as we know, a lectotype has not been selected from the syntypes. The date range for syntype 2 is when Motley was in Singapore, and the collection number is from the syntypes in PC.

Illustrations: Fig. 6. Also Ellis and Tan (1999, page 33).

Description: Plants to 2.5 cm tall, mostly shorter, green to yellowish green or brownish to reddish-brown, in bristly tufts and cushions. Stems mostly simple, erect, with copious reddish-brown to purple rhizoids. Leaves usually straight and stiffly erect wet or dry, mostly 4–9 mm long, the bases usually orange-red tinted; apex variable, usually blunt or broadly acute; limb linear to broadly linear; upper margins thickened with an internal stereome surrounded by short chlorophyllose cells, often coarsely and irregularly toothed, the teeth often paired; margin just above leaf shoulders irregularly spinose-serrate (sometimes almost entire) with coarse teeth; gemmiferous leaves slightly narrower, ± tubular and stiffer than vegetative leaves. Costa strong, scabrid abaxially; in section biconvex to ± circular, with 4–6 guide cells, thick adaxial and abaxial stereid bands, and an epidermal layer of conical subspiniform chlorocysts. Cells of upper chlorophyllose lamina small, ± obscure, smooth to bulging abaxially, strongly conical-papillose adaxially; lamina cells adjacent to hyaline lamina typically orange-red, composed of elongate-rectangular cells with thick-walled and strongly pitted or porose walls; hyaline lamina scalariform to rounded distally. Gemmae fusiform-clavate, common. Sporophytes not seen in Australian material and apparently uncommon elsewhere.

Etymology: Latin *croceus* (saffron), referring to the saffron colour that suffuses the basal cells in re-wetted leaves.

Distribution: North-eastern Queensland, from Iron Range south to Cardwell and Hinchinbrook Island (Fig. 21.6). Elsewhere known from the Seychelles, widespread in more oceanic areas of tropical Asia from Sri Lanka and Thailand to Malesia, Borneo, Philippines, Micronesia, Papua New Guinea, Western Samoa, east to Polynesia, New Caledonia.

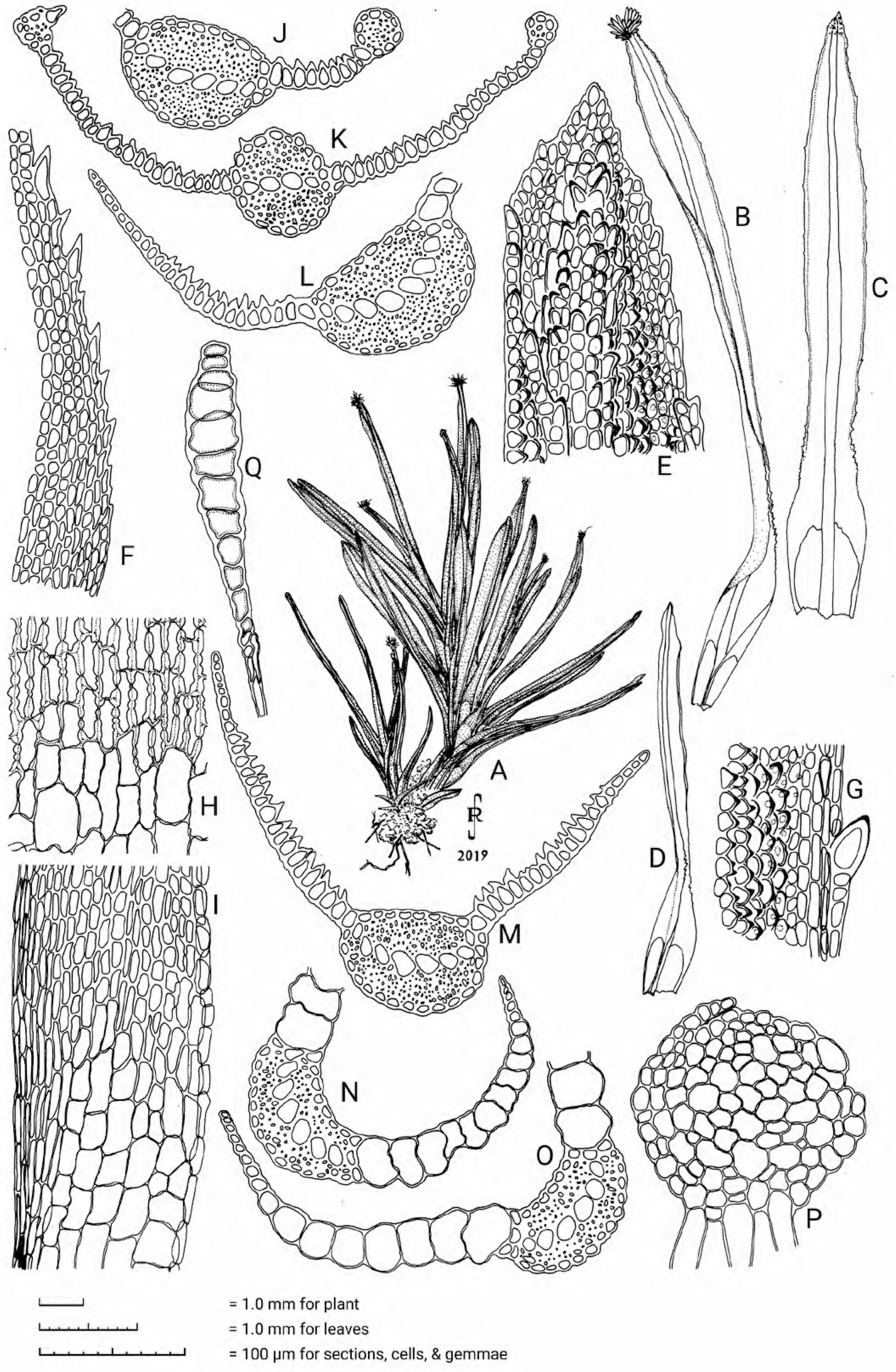


Fig. 6. *Syrrhopodon croceus* Mitt. **A:** Habit of plants, drawn moist. **B–D:** Leaves. **E:** Cells of leaf apex, adaxial view, gemmae removed. **F:** Marginal cells from mid to upper leaf limb. **G:** Marginal cells of lower leaf limb, lust above shoulder region. **H:** Cells at the base of the leaf limb and distal end of hyaline lamina. **I:** Cells of hyaline lamina. **J–M:** Sections of leaf limb. **N, O:** Sections of hyaline lamina. **P:** Stem section. **Q:** Gemma. Drawn from: *A.J.Franks AJF1411001B*.

Habitat: On the trunks of living and dead trees, rarely on boulders, from sea level to about 800 m a.s.l.; occasionally on mangroves.

Recognition: *Syrrhopodon croceus* is easily recognised by its erect bristly habit and the often highly pigmented (orange-red) leaf bases. The hyaline lamina is also often eroded. *Syrrhopodon muelleri* has a similar habit but the leaves are yellowish-green with entire margins and lack the pigmented leaf bases. The stems are also very short, the plants appearing almost stemless, and the leaves are often twisted. Leaves of *S. croceus* may also be almost 'petiolate', constricted between the broader sheathing base and the upper limb.

Selected specimens seen: Queensland: Fishery Falls near Gordonvale, *A.Cairns B-326*, BRI AQ0649297; western side of Mount Tozer, *J.R.Clarkson 2912*, July 2005, BRI AQ0575987; Bramston Beach Road, 6.3 km from Bramston Beach, *A.J.Franks AJF1411001B*, 7 November 2014, BRI AQ0910204.

7. *Syrrhopodon cyrtacanthos* W.D.Reese, *Bryologist* 95: 95, figs 1–6 (1992).

Original material: 'Australia. Queensland: Roaring Meg Creek, on bark (with its accumulated soil) of *Syzygium dyctiophlebium* (weather often cloudy here), about 1,200 ft., 1984, *Michael Godwin s.n.* in herb. MELU sub I. G. Stone 23001.'

Type: Australia, Queensland, Roaring Meg Creek, *M.Godwin s.n.,* 1984; holotype: MEL2341363!d ex MELU (herb. I.G.Stone 23001); isotypes: MO 406876/A, BC 5912383, *fide* Tropicos [https://www.tropicos.org/name/35186344] (not seen).

Illustrations: Fig. 7. Also Reese (1992: 94).

Description: Plants small, glaucous green, to 5 mm tall, gregarious. Stems erect, simple; rhizoids dark red. Leaves ascending, straight or curved, little altered wet or dry, linear-acuminate from a slightly broader sheathing base, 2–3 mm long; apex acute; leaf margins entire, involute distally, bordered from base to apex with multistratose slender, elongate hyaline cells. Costa strong, excurrent into a pale, slender, short subulate apex, spinose abaxially near the tip, mostly smooth below or irregularly spinose adaxially and with occasional spines along abaxial flanks, ± circular in section, with 2–4 guide cells, strong adaxial and abaxial stereid bands, differentiated epidermal layer smooth or occasionally with cells bearing spiculose papillae. Cells of mid chlorophyllose lamina quadrate to rectangular, thick-walled, about 8–11 μm, adaxially unispiculose-spinose with tall, acute papillae, abaxially unipapillose or with stout, sharp ± spiculose or apically divided papillae; in apical part of limb abaxial papillae tall, slightly to strongly curved, pointing distally; hyaline lamina narrow, scalariform, the distal margins ± convex. Gemmae borne adaxially near leaf tips but well-developed gemmae not seen. Perigonia axillary, gemmiform, of several tiny reddish leaves enclosing a few antheridia. Perichaetia and sporophytes not seen.

Etymology: Greek *kyrtos* (curved) + *akanthos* (a thorny plant), referring to the curved, thorn-like papillae on the leaves.

Distribution: An Australian endemic, known only from the type locality in north-eastern Queensland (Fig. 21.7).

Habitat: The only known specimen was growing on the bark of a *Syzygium dictyophlebium* (with some accompanying soil) at 700 m a.s.l. in upland rainforest.

Recognition: The species was described from a single, rather depauperate specimen (Reese 1992). Reese and Stone (2012) noted that the species is distinctive because of the entire leaf margins and heavily armed cells. *S. prolifer* has uniformly pluripapillose cells with much shorter, non-spinose papillae, and *S. involutus* has a very short limb with the cells smooth or inconspicuously unipapillose.'

Bordering the costa, at least distally, the cells of the chlorophyllose lamina are larger and quadrate to short rectangular, often without spiculose papillae, 10–15 μm long, 8–15 μm wide.

Selected specimens seen: Queensland: Roaring Meg Creek, Daintree National Park, Cape Tribulation. *M.Godwin s.n.* 1984, MEL 2341363.

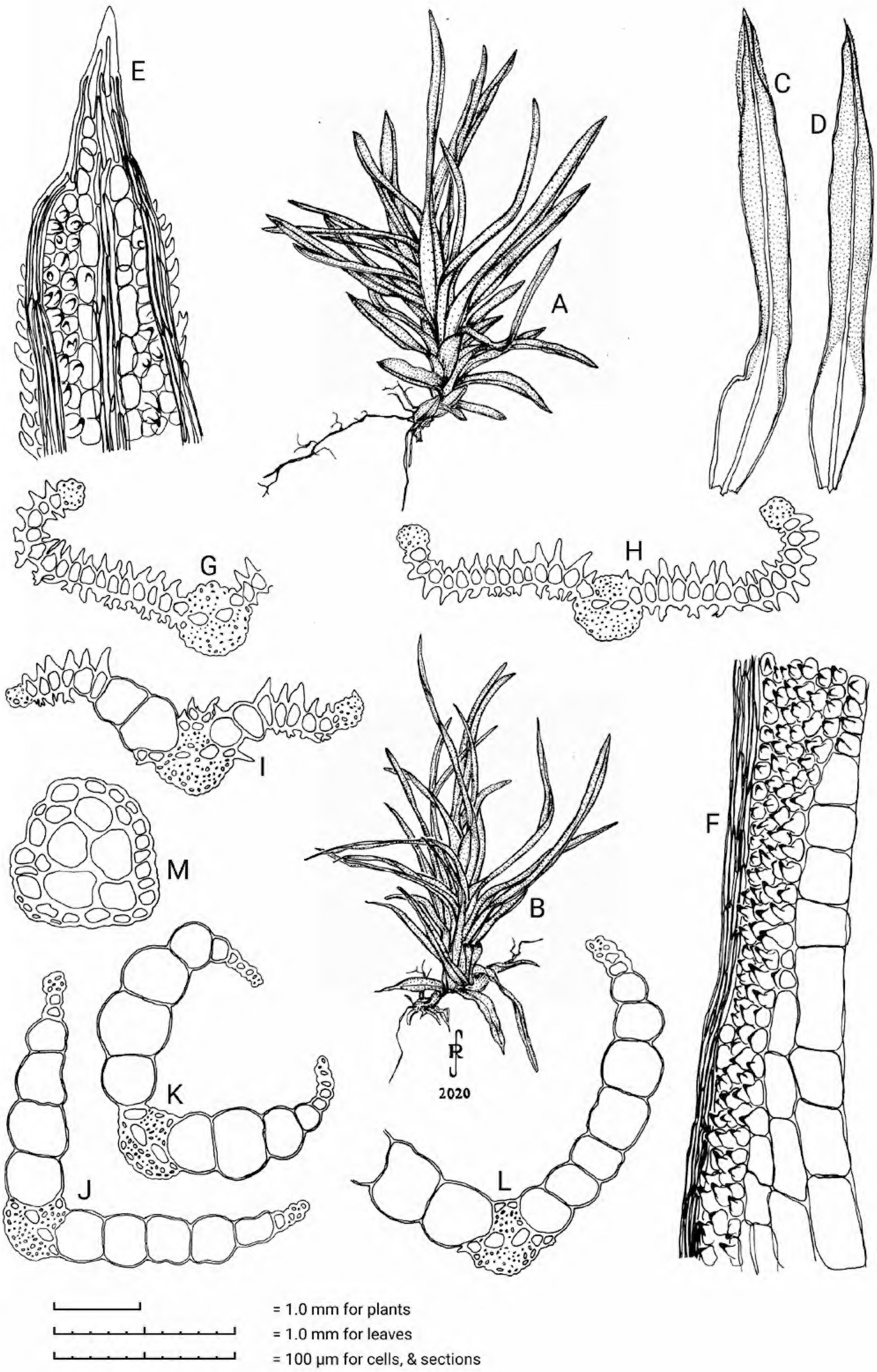


Fig. 7. *Syrrhopodon cyrtacanthos* W.D.Reese. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C, D:** Stem leaves. **E:** Cells of leaf apex, abaxial view. **F:** Cells of hyaline lamina. **G, H:** Sections of leaf limb. **I:** Section of distal end of hyaline lamina. **J–L:** Sections of sheathing leaf base. **M:** Stem section. Drawn from *M.Godwin s.n.* (sub *I.G.Stone 230001*).

8. *Syrrhopodon gardneri* (Hook.) Schwägr., *Spec. Musc. Suppl.* 2(2): 110, pl. 131 (1824).

Basionym: *Calymperes gardneri* Hook., *Musci Exotici* 2: 146 (1819).

Original material: 'Hab. In Nepal, arboribus. Hon. D. Gardner.'

Type: Nepal, s. *loc.*, *Edward Gardner s.n.*, 1815–1819; suntypes: BM000676896!d, BM000676900!d, BM000676903!d, BM000676904!d, NY 01113938!d.

Note: E00011916!d, E00011917!d, E00261795!d, are annotated as types, attributed to Joseph Hooker as the collector, but Hooker's collections are not specifically cited in the protologue, so they are here excluded from type status, though they are probably original material. It is also possible that they are duplicates of the type from Hooker's herbarium and an assumption was made that he collected them.

Illustrations: Fig. 8. Also Hooker (1819: 146), Reese and Lin (1991: 344), Ellis and Tan (1999: 36).

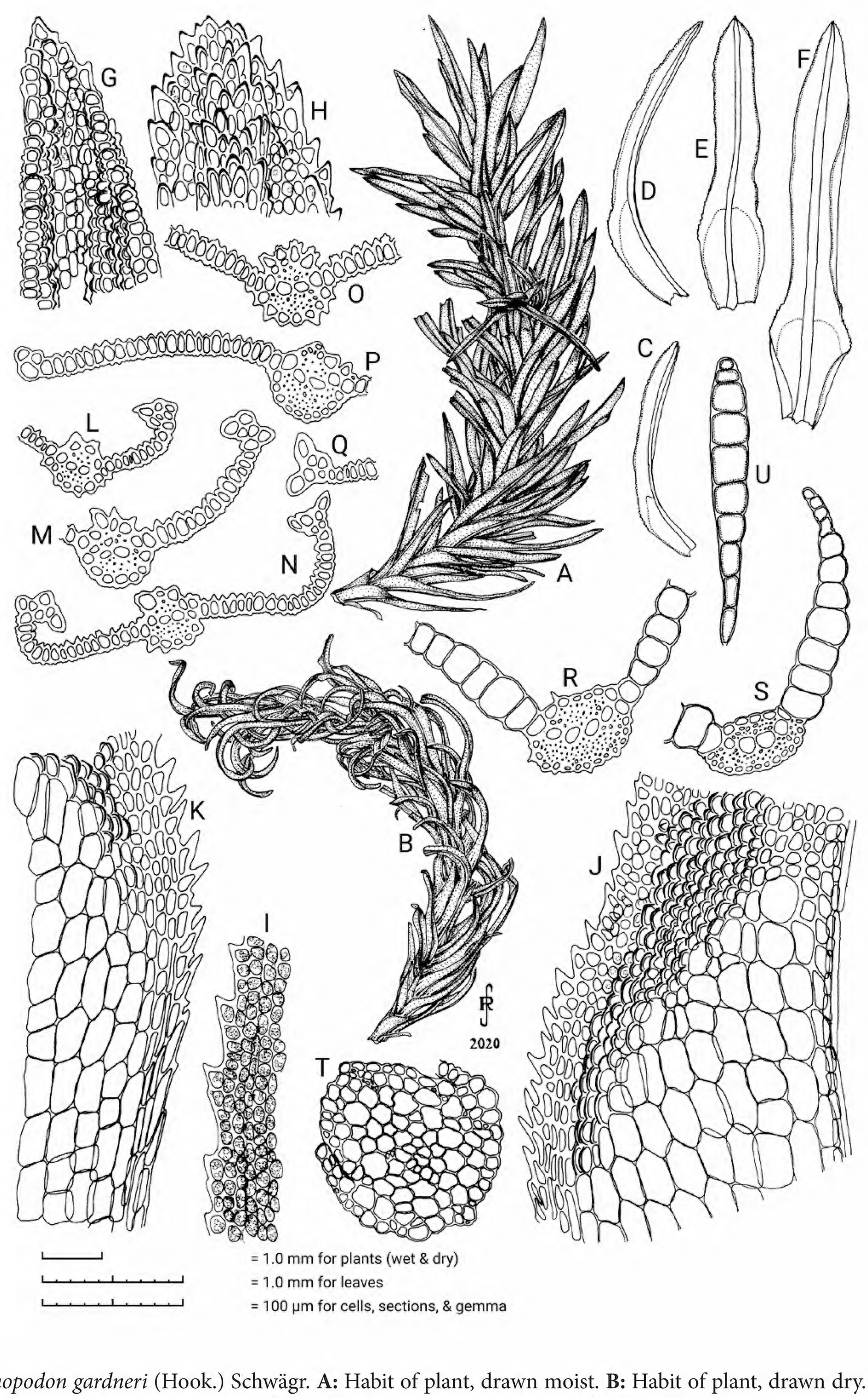


Fig. 8. *Syrrhopodon gardneri* (Hook.) Schwägr. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C–F:** Stem leaves. **G:** Cells of leaf apex, adaxial view. **H:** Cells of leaf apex, abaxial view. **I:** Cells of mid-limb margin. **J, K:** Cells of hyaline lamina and margin of sheathing base. **L--P:** Sections of leaf limb. **Q:** Cells of leaf margin, in section. **R, S:** Sections of sheathing leaf base. **T:** Stem section. **U:** Gemma. Drawn from: *H.Streimann 42356*.

Description: Plants medium-sized, yellowish-green to brownish-green above, brown below, forming loose mats or tufts. Stems to 4 cm tall; rhizoids dark red to purple, often abundant and conspicuous. Leaves rigid or flexuose when moist, variously incurved and contorted when dry, from an appressed and convolute sheathing base abruptly narrowed to a linear spreading limb, 2–4(–5) mm long, c. 0.7 mm wide at shoulders, 0.3 mm wide in limb, linear-lanceolate; apex subacute to obtuse, serrate; margins weakly bordered in shoulders and limb, coarsely toothed, the shoulders with sharp spreading or ascending teeth. Costa prominent, ending shortly below apex, hispid both adaxially and abaxially, with short, strongly projecting cells; in section ± circular, with about 4 guide cells, adaxial and abaxial stereid bands and differentiated epidermal layer of conically projecting cells. Cells of chlorophyllose lamina rounded-quadrate, 8–12 μm wide, thick-walled, abaxial surface pluripapillose, adaxial surface partly obscured by tall conical mammillae; chlorophyllose cells adjacent to hyaline lamina typically with forward directed projecting ends. Hyaline lamina sharply delimited, in about 8–10 rows either side of costa, ending in a broad angle on the costa just below shoulders; cells of chlorophyllose lamina decurrent down margins of hyaline lamina. Sporophytes unknown in Australian collections. Gemmae clavate, c. 200 μm long.

Etymology: After Colonel Edward Gardner (1784–1861), British ambassador and botanical collector in Nepal, who collected the type. His first initial was mistakenly rendered as 'D' in the type citation. BM material is annotated 'Nepal. Hon. Col. (or Col^{l}.) Gardner', but JSTOR Global Plants strangely attributes all the BM collections to George Gardner (a Scottish biologist born in 1810) and cites a collecting number H1205, which was merely a herbarium number.

Distribution: In Australia *Syrrhopodon gardneri* is known only from Arnhem Land in the Northern Territory, where it grows on rock in monsoon forest, and Babinda Boulders in the Queensland Wet Tropics, where it grows on the trunk of an isolated rainforest tree (Fig. 21.8). Elsewhere, a widespread pantropical species, from Central America, Central and Western Central Africa, Madagascar, Réunion, tropical Asia, India, Sri Lanka, China (Guangdong, Hainan, Yunnan), Malesia, Borneo, Sulawesi.

Recognition: It is distinguished from all other Australian *Syrrhopodon* species by its usually abundant and conspicuous dark red rhizoids, sharply dentate-serrate leaf shoulders, and the absence or elongated marginal hyaline cells. It is generally an upland species elsewhere in its range, growing on the bark of forest trees, rotting logs and humus, rather than on rock, from sea level to about 2000 m a.s.l., but rarely below 1000 m (Eddy 1990, Reese *et al.* 1991). *Syrrhopodon gardneri* is similar in growth form to *S. spiculosus* and *S. prolifer*, but readily distinguished from the former by the lack of a marginal stereome and simple papillae on mid-limb chlorophyllose cells, while *S. prolifer* has a smooth, not hispid, costa.

Selected specimens seen: Queensland: *B.O.van Zanten 681001*, 20 July 1968, NSW 896864. Northern Territory: Baroalba Creek, 15 km south-southeast of Jabiru Airfield, *H.Streimann 42356*, 22 April 1989, CANB 8914883.

9. *Syrrhopodon involutus* Schwägr., *Spec. Musc. Suppl.* 2(2): 117, pl. 132 (1824).

Original material: 'In insula Rauwack Moluccensi legit cl. Gaudichaud socius navarchi Freycinet, ad ligna putrida.'

Type: Indonesia: Rawak, Maluku Islands, *C.Gaudichaud-Beaupré 11/26, s.d.* (before 1824); isotypes: BM000672900!d, BM000672901!d, E00261792!d, PC0100937!d, PC0100938!d, PC 0100939!d, PC01009340!d.

Note: The collection number is taken from E00261792.

Illustrations: Fig. 9. Also Reese and Lin (1991: 352), Ellis and Tan (1999: 38).

Description: Plants small, pale green to whitish, often in compact tufts. Stems slender, reddish, frequently branched; rhizoids purplish to brownish red. Leaves small, ascending, straight and little contorted when wet or dry; narrow lanceolate, densely imbricate, 1.5–3.5 mm long, 0.4–0.5 mm wide, tapering quickly above to an acute apex. Leaf margins erect, involute or revolute, entire, bordered by a narrow stereome of elongate hyaline cells. Costa narrow, about 30 μm wide abaxially, narrower on adaxial side, percurrent or ceasing shortly below leaf tip, or ending in a short mucro; abaxially ± smooth to somewhat mammillose at apex; in section, with two small guide cells and small adaxial and larger abaxial stereid bands, and typically on adaxial surface with two rows of thick-walled rectangular epidermal cells with a row of larger thin-walled hyalocysts on either side. Chlorophyllose lamina small in area and confined to apical region of leaf but lamina cells decurrent down leaf margin; cells quadrate to rectangular, pellucid, 8–10 μm wide, to 15–20 μm long, smooth walled or unipapillose. Hyaline lamina large, comprising much of leaf, sharply defined, cells scalariform in 3–6(–8) rows either side of costa. Gemmae sparse, fusiform-clavate, borne adaxially along costa at leaf tip. Sporophytes not seen in Australian material.

Etymology: Latin *involutus* (rolled), referring to the inrolled leaf margins.

Distribution: North-eastern Queensland, from Mossman Gorge to Cardwell (Fig. 21.9). Also widespread in the tropics and subtropics, from Africa and the East African islands (Madagascar, Réunion), Asia, Malesia, the Philippines, Papua New Guinea and the Pacific islands.

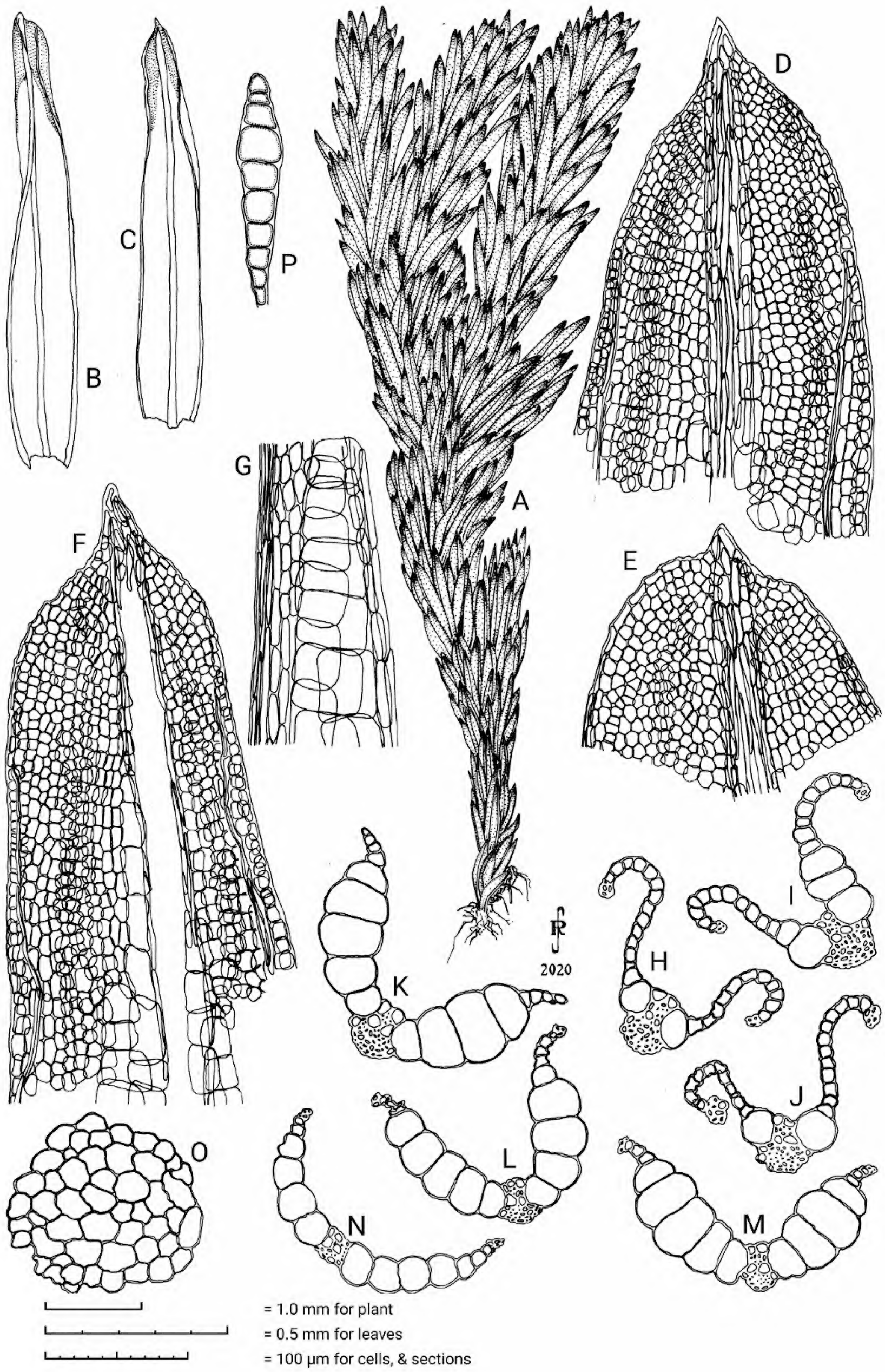


Fig. 9. *Syrrhopodon involutus* Schwägr. **A:** Habit of plant, drawn moist. **B, C:** Stem leaves. **D–F:** Cells of leaf apex. **G:** Cells of distal hyaline lamina. **H–J:** Sections of leaves near leaf apex. **K–M:** Sections of leaf limb. **N:** Section of leaf near insertion. **O:** Stem section. **P:** Gemma. Drawn from *I.G.Stone 24537*.

Habitat: *Acacia* and *Melaleuca* trunks in coastal notophyll vine forest, and in mesophyll vine forests on trees, rotting wood and boulders, mostly at low elevations but up to 1000 m a.s.l.

Recognition: Eddy (1990) remarked on the variability of the prominence of the chlorophyllose lamina and costal cell papillosity, the cells often being ± smooth, as shown in Fig. 9. Reese *et al.* (1986) remarked that *S. involutus* 'is a wide-ranging and complex assemblage of forms' and that 'the name *S. involutus* should refer to plants with strongly involute margins, and cells conspicuously papillose dorsally and ventrally', but this expression 'apparently intergrades with other forms having the margins plane to revolute and cells smooth to papillose and the upper lamina shorter [less than half the length of the lower lamina]'. In the expression shown in Fig. 9 the chlorophyllose lamina is very much reduced in area (Fig. 9 B, C), the lamina cells are smooth and the leaf margins are clearly revolute.

Syrrhopodon confertus may be confused with *S. involutus*, but in the former species the leaf margin is clearly dentate and the leaves are spreading and ascending.

Selected specimens seen: Queensland: North Kennedy District; Cardwell, Sullivan's Track, *I.G.Stone 24537*, 22 July 1987, MEL 2326285.

10. *Syrrhopodon katemensis* (Zanten) L.T.Ellis, *Syst. Biodivers.* 1: 164 (2003).

Basionym: *Calymperopsis katemensis* Zanten, *Nova Guinea, Bot.* 10(16): 282, pl. 24, fig. 3 (1964).

Original material: Original publication not seen.

Type: Indonesia: Irian Jaya, Katem, 200 m, *B.O. van Zanten 286a*, 17 June 1959; holotype: L0060751, not seen; isotypes: BM000675257!d, GRO not seen.

Australian synonym: *Syrrhopodon prolifer* Schwägr. var. *mossmanensis* W.D.Reese, *Bryologist* 92: 303, figs 4–6. 1989, *fide* Ellis (2003). **Original material:** 'Lower High Falls, N of Mossman, 16°28S, 145°16E, on tree trunk, *W. B. Schofield, I. G. Stone & M. I. Schofield 90033'*. **Type:** Australia: Queensland, Lower High Falls, *W.B.Schofield 90033, I.Stone & M.Schofield*, 5 Sep 1987; holotype UBC117879!d, isotypes MO406960!d, LAF not seen, MELU!, NSW not seen.

Illustrations: Fig. 10. Also Reese (1989: 303); Orbán and Reese (1990: 44).

Description: Plants in loose tufts, pale glaucous green, to 10 mm tall. Stems reddish below, erect, simple or branched; rhizoids red. Leaves twisted and contorted when dry, 1.5–3.5 mm long, 0.5–0.75 mm wide in mid limb, the limb 1.5–2 times longer than sheathing base, often bearing low dense tufts of rhizoids at tips; margins entire, bordered all round by elongate hyaline cells. Costa ending in or just beyond apex, in section with 2(-4) median guide cells, adaxial and abaxial stereid bands, epidermal layer not differentiated. Cells of chlorophyllose lamina at mid limb about (6–)8–10(–12) μm, thick-walled, with stout multifid papillae adaxially and abaxially; hyaline lamina ending acutely distally, chlorophyllose cells shortly decurrent down margins. Gemmae scarce, clavate, 60–100 μm long, in clusters on adaxial surface of costa at leaf tips, sometimes mixed with leaf-borne rhizoids. Sporophytes not known in Australian material.

Etymology: Katem + *–ensis* (coming from), referring to the locality of the type collection, Katem in Indonesia.

Distribution: North-eastern Queensland, near Mossman and the Paluma Range (Fig. 21.10). Also Indonesia (Irian Jaya).

Habitat: Trunks of large trees in humid sites along streams and rivers, to about 500 m a.s.l.

Recognition: *Syrrhopodon katemensis* (as *S. prolifer* var. *mossmanensis* in Reese and Stone 2012) differs from *S. prolifer* var. *prolifer* by the somewhat shorter leaves, cells of the chlorophyllose lamina being slightly larger and having tall, stout multifid papillae on both surfaces. The specimen used for illustration was collected from 2 m up the trunk of a large tree growing in rainforest along the edge of a swift flowing, rocky, mountain stream.

Originally described as *Calymperopsis katemensis* by van Zanten (1964), the species was synonymised under *S. trachyphyllus* Mont. by Reese *et al.* (1986), Eddy (1990) and Menzel and Schultze-Motel (1990). However, Ellis (2003) noted that '*Calymperopsis katemensis* Zanten (= *Syrrhopodon katemensis* (Zanten) L.T.Ellis) has distinctive features such as a smooth costa and a chlorophyllose lamina composed of tiny, densely papillose cells, and appears sufficiently different from *S. prolifer* Schwägr. and other taxa to justify its status as a species.' We agree with this conclusion.

Selected specimens seen: Queensland: along Whyanbeel Road, north-northwest of Mossman, *W.D.Reese 17515*, 09 June 1989, MEL 2393230A; Mount Lewis, near Mossman, *B.O.van Zanten 681386*, 4 Aug 1968, NSW 896637.

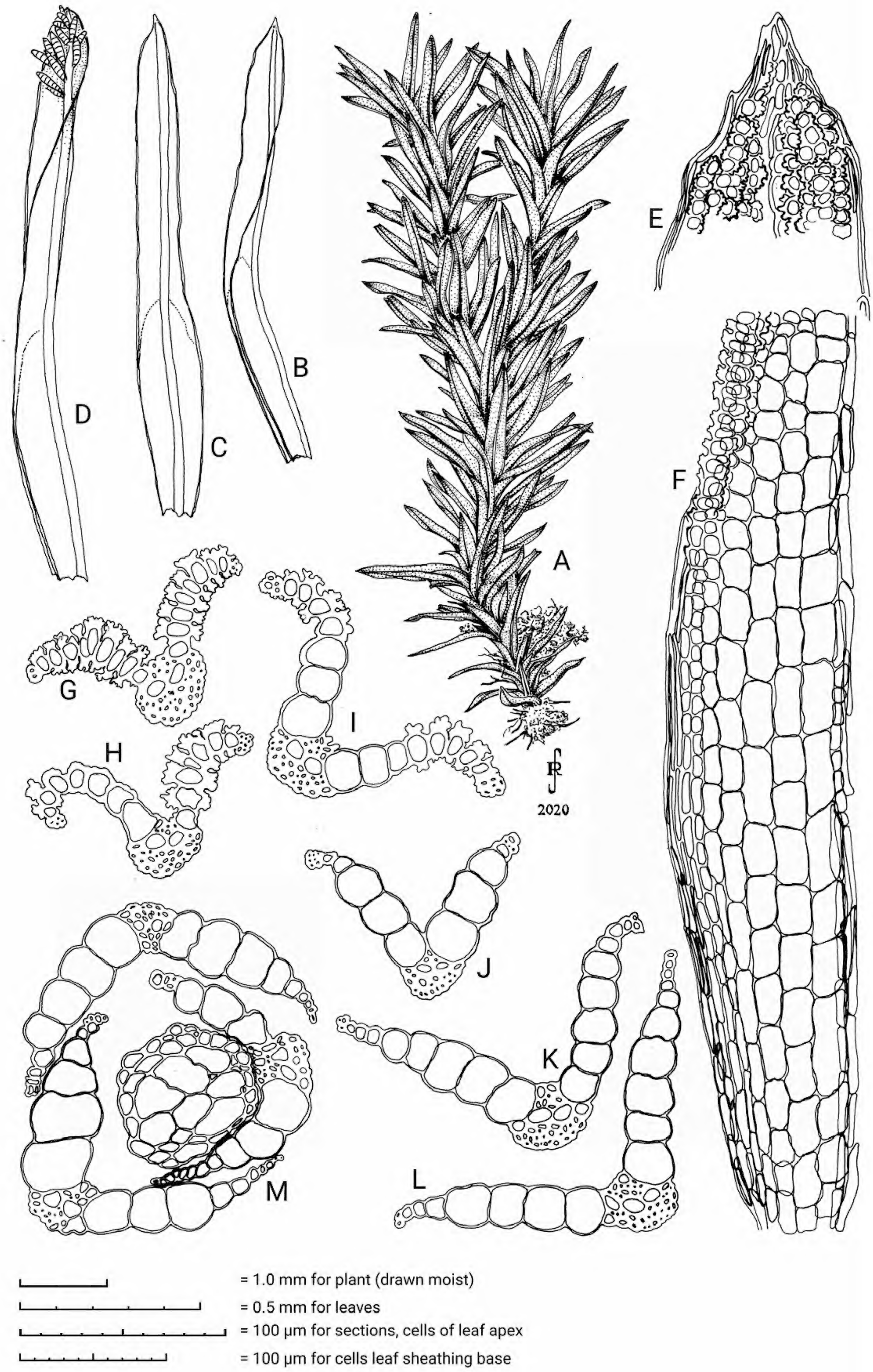


Fig. 10. *Syrrhopodon katemensis* (Zanten) L.T.Ellis. **A:** Habit of plant, drawn moist. **B, C:** Stem leaves. **D:** Gemmiferous leaf. **E:** Cells of leaf apex, adaxial view. **F:** Cells of hyaline lamina. **G, H:** Sections of upper leaf limb. **I:** Section of distal end of hyaline lamina and lower leaf limb. **J–L:** Sections of sheathing leaf base. **M:** Section of stem and sheathing bases of subtending leaves. Drawn from: *W.D.Reese 17515*.

11. *Syrrhopodon muelleri* (Dozy & Molk.) Sande Lac., *Bryol. Jav*. 2: 224 (1870).

Basionym: *Calymperidium muelleri* Dozy & Molk., *Bryol. Jav*. 1: 51, t. 42 (1856).

Original material: 'Habitat insulam Javae, legit Holle.'

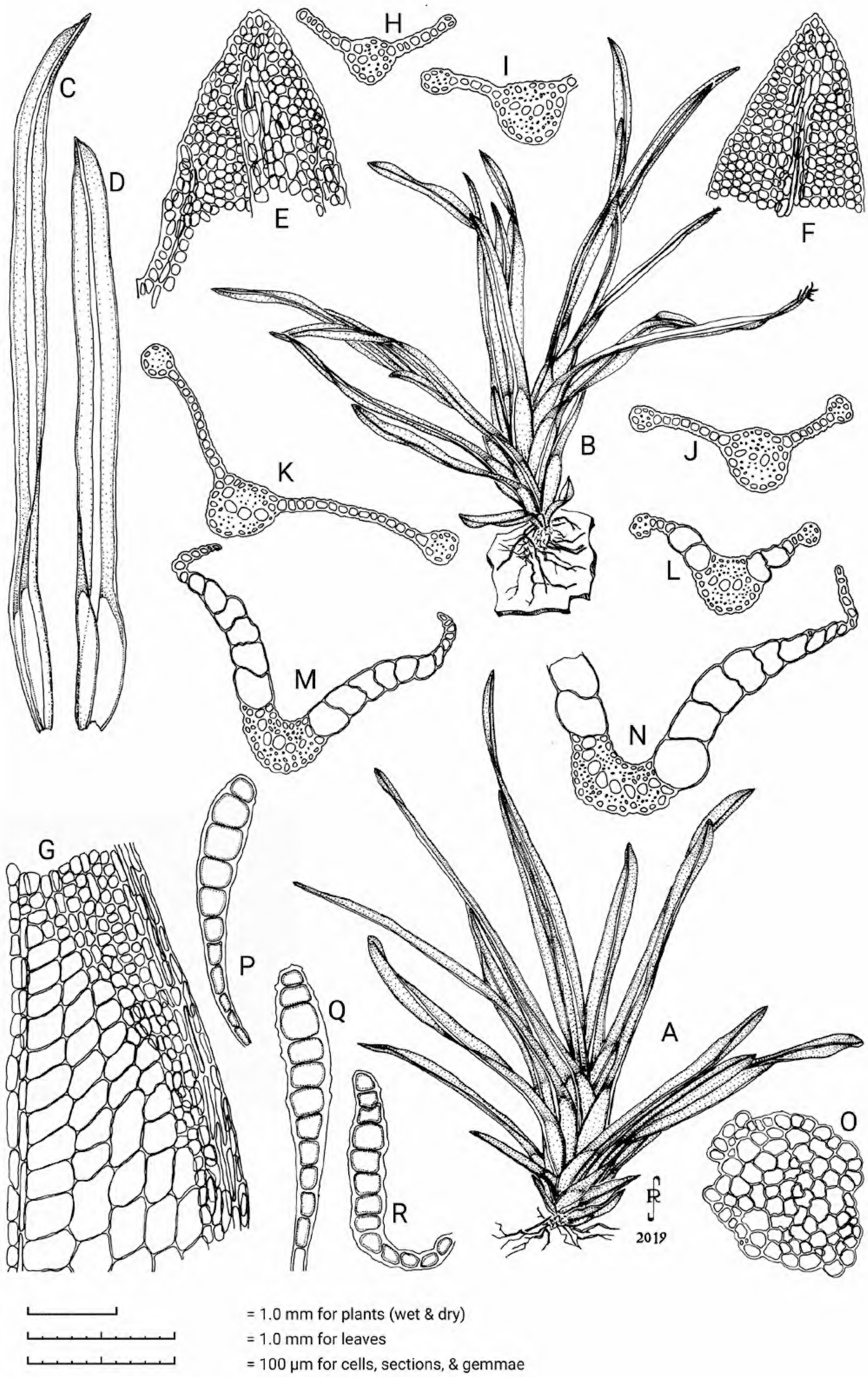


Fig. 11. *Syrrhopodon muelleri* (Dozy & Molk.) Sande Lac. **A, B:** Habit of plants, drawn moist. **C, D:** Stem leaves. **E:** Cells of leaf apex, adaxial view. **F:** Cells of leaf apex, abaxial view. **G:** Cells of hyaline lamina. **H–K:** Sections of leaf limb. **L:** Section of leaf at base of limb and distal hyaline lamina. **M, N:** Sections of leaf sheathing base. **O:** Stem section. **P–R:** Gemmae. Drawn from *W.D.Reese 17102*.

Type: Indonesia: Java, *G.K.von Holle* s.n., s.d. (before 1856); holotype: L0624128 not seen; isotypes: L0060726 not seen, L0060725 not seen, L0624127 not seen; all *fide* Touw (2013).

Note: Two collections in NY (NY01114107!d, NY01114108!d) are annotated by Bill Reese as probable isotypes, but we can see no evidence to support this.

Illustrations: Figure 11. Also Dozy and Molkenboer (1856: 51, t. 42, figs 1–23); Reese and Lin (1991: 364, fig. 131); Ellis and Tan (1999: 40, fig. 22a–f).

Description: Plants reaching 7–12 mm tall, yellowish-green, forming thin tufts. Stems erect, mostly simple, very short, the plants appearing ± stemless; rhizoids brown to reddish-brown. Leaves long and narrow, stiffly erect when wet or dry, occasionally twisted, narrowly linear, 8–15 mm long, 0.2–0.3 mm wide in limb, sheathing base short, 1.0–1.5 mm long, about 0.4 mm wide; leaf apex broadly acute; margins entire; leaves bordered all round with a colourless to yellowish marginal stereome, continuing to the upper sheathing base where superficial layer of laminal cells is lost. Costa strong, to about 95 μm wide in mid limb, smooth, ending below leaf tip; in section, ± plane adaxially, rounded abaxially, with 4–8 guide cells, adaxial and abaxial stereid bands and epidermal layer of lamina cells. Cells of chlorophyllose lamina isodiametric, smooth or very finely pluripapillose, 6–9 μm wide. Hyaline lamina sharply delimited, narrow, extending into base of limb, chlorophyllose cells decurrent down margins; weakly scalariform. Gemma common, clavate, borne adaxially on leaf tips. Sporophytes not seen in Australian material.

Etymology: After German bryologist Carl Müller (1818–1899) of Halle.

Distribution: North-eastern Queensland, from Cooktown to Tully (Fig. 21.11). Also tropical Asia, India, Sri Lanka, Thailand, China, Malesia, Borneo, Sulawesi, Philippines, Papua New Guinea, Western Samoa, Fiji, Hawaii.

Habitat: Epiphytic on trees, rarely on soil, in complex mesophyll vine forests, to about 800 m a.s.l.

Recognition: The straw colour, ± stemless habit, erect and entire-margined and often twisted leaves are distinctive characters. *Syrrhopodon aristifolius* is also ± stemless but there the leaves are often ± petiolate, constricting above the sheathing base before widening into the limb. The leaf margins are also smooth but not hyaline and in section, angular not rounded, with the leaf apex narrower and tapering to a point. The marginal stereome of *S. aristifolius* also continues down the leaf shoulder margin. *Calymperes serratum* also has ribbon-like flexuose leaves but the leaf shoulders are serrate.

Selected specimens seen: Queensland: Bellenden Ker Range, near Telecom Station at foot of cable car lift, *W.D.Reese 17102*, 19 July 1987, NSW 750952, CBG 9207515.1.

12. *Syrrhopodon parasiticus* (Sw. ex Brid.) Besch., *Ann. Sci. Nat. Bot., Sér.* 8, 1: 298 (1896).

Basionym: *Bryum parasiticum* Sw. ex. Brid., *Muscol. Recent.* 2(3): 54 (1803).

Original material: 'In Jamaica ad arbores ? habitat.'

Type: Hispaniola (Greater Antilles), s.loc., ?*Swartz s.n.*, 1759; isotypes: BM000664063!d, BM000664065!d, BM000664066!d, E00002338!d.

The collection date is taken from an annotation on E00002338. Bridel-Brideri stated that the species was unknown to him, and that he took the description from Swartz (i.e. Olof Swartz, in *Nova genera et species plantarum* 1788: 139), so the authorship must be Sw. ex Brid., even though Swartz's publication pre-dates Hedwig (1801). Although most species described by Swartz were from Jamaica, he listed *Bryum parasiticum* from Hispaniola, in the Greater Antilles (annotated as such on E00002338). This should therefore be treated as an error by Bridel-Brideri in the type citation cited above. Since Hispaniola is now shared by Haiti and the Dominican Republic, it is not possible to state the modern country where the type was collected.

Australian synonym: *Syrrhopodon wattsii* Broth., *Öfvers. Finska Vetensk.-Soc. Förh.* 43: 93 (1900); *Calymperopsis wattsii* (Broth.) M.Fleisch., *Biblioth. Bot.* 80: 5 (1913), *fide* Reese and Stone (2012). **Original material:** 'New South Wales, Richmond River, Wardell Road, ad truncum arboris parcissime (W. W. Watts n. 2420).' **Type:** Australia: New South Wales, Pimlico, Richmond River, *W.W.Watts 2420*, 12 Aug 1901; holotype: S (*fide* Reese and Stone 2012), not seen; isotypes: NSW (*fide* Reese and Stone 2012) not seen, MEL 1002944A!, PC 0131479!d.

Notes: The collecting date is taken from a label on the isotype packet in MEL, and agrees with the date stated on the isotype packet in PC ('Aug 1901'). Watts made numerous collections of plants at Wardell Road in the Richmond River district on 18 August 1901, but the known collecting numbers are in the range 5042 to 5054 (AVH 2022). It is thus possible that the number cited in the protologue was misread from handwriting. However, the year of publication, as stated on the title page of the journal, was 1900, and the article by Brotherus

is dated November 1899, thus preceding the supposed collecting date by almost two years. Unfortunately it was beyond the scope of this study to resolve this disparity.

Illustrations: Fig. 12. Also Reese *et al.* (1986: 175), Eddy (1990: 89), Reese and Lin (1991: 363), Ellis and Tan (1999: 40).

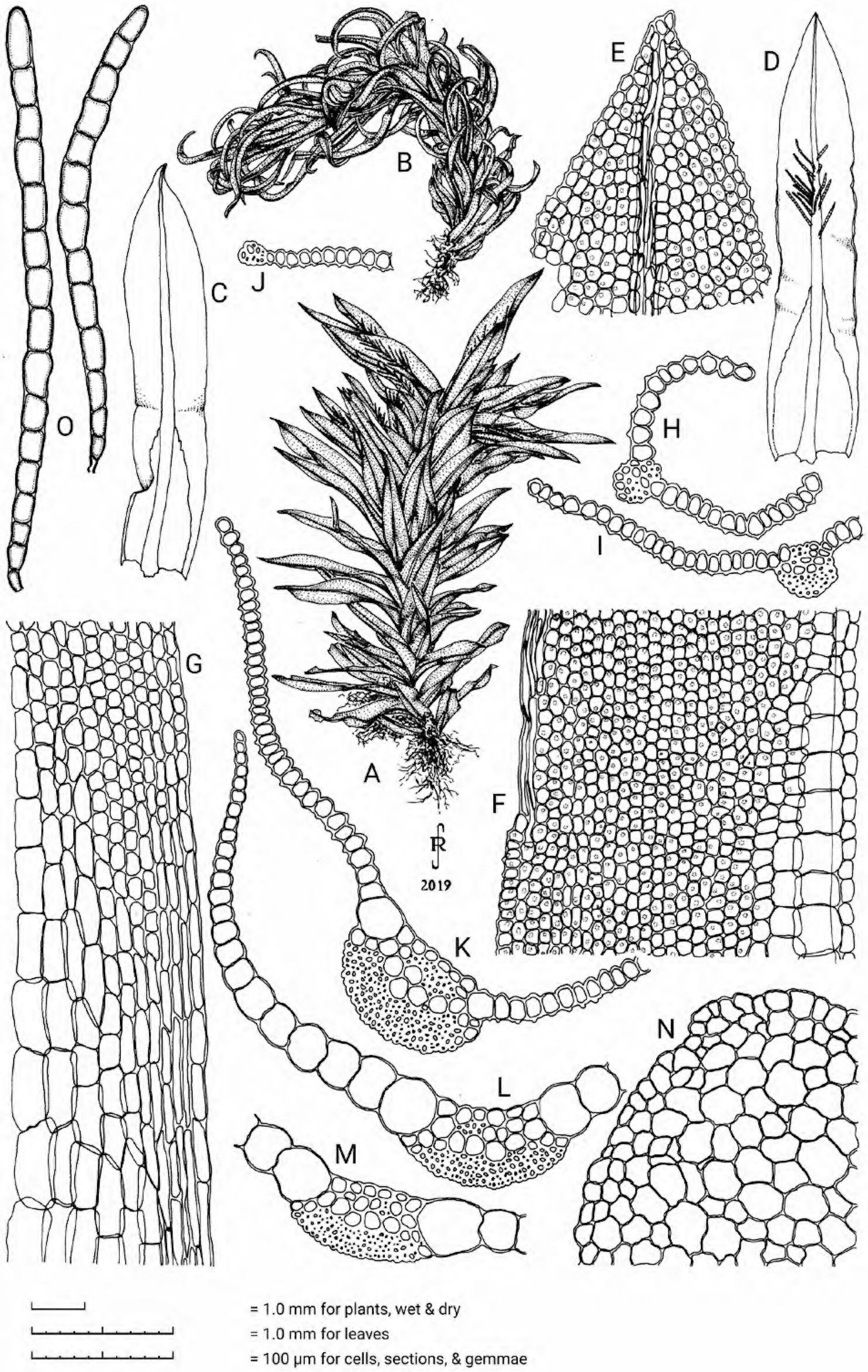


Fig. 12. *Syrrhopodon parasiticus* (Brid.) Besch. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C:** Non-gemmiferous leaf. **D:** Gemmiferous leaf. **E:** Cells of leaf apex, abaxial view. **F:** Cells of distal hyaline lamina and lower leaf limb. **G:** Cells from basal margin of leaf. **H, I:** Leaf sections from upper limb. **J:** Section of margin of leaf limb. **K:** Section of base of limb at distal hyaline lamina. **L, M:** Sections of leaf base. **N:** Part stem section. **O:** Gemmae. Drawn from *D.A.Meagher and A.Cairns WT-604B*.

Description: Plants small, to 10 mm tall, dark green, in small, open colonies or solitary. Stems erect, mostly simple; rhizoids brown. Leaves 3–4 mm long, 0.6–0.7(–0.85) mm wide at mid limb, the lamina weakly undulate, narrow lanceolate to lingulate; margins entire, bordered in part by hyaline cells, the border ending well below the leaf apex and at the shoulder region, sometimes weak or lacking in some leaves. Costa percurrent, in section with 4–6 median guide cells and often a few additional guide cells adaxially, abaxial stereid band larger than adaxial band, epidermal layer lost abaxially in lower limb, adaxially ± distinct throughout. Cells of chlorophyllose lamina rounded-polygonal, 5–7 μm wide, abaxially smooth to unipapillose with simple papillae, convex adaxially. Hyaline lamina sharply defined, narrowing gradually upwards and penetrating well into base of the limb, scalariform. Gemmae often numerous, filamentous, arising from adaxial surface and edges of costa, mainly near mid limb. Sporophytes not seen in Australian material.

Etymology: Latin *parasiticus* (parasitic), presumably referring to the epiphytic habitat.

Distribution: Eastern Queensland, from Mossman southwards, extending into northern New South Wales (Fig. 21.12). A pantropical species recorded from southern USA, Central America, tropical northern South America, west Central Africa, east Central Africa, Madagascar, Réunion, tropical Asia, China, Malesia, Borneo, Philippines, Polynesia, Oceania.

Habitat: Epiphytic on twigs and bark of trees from sea level to about 1000 m.

Recognition: *Syrrhopodon parasiticus* is inconspicuous in the field because it seems to always grow in small, sparse colonies. Reese and Stone (2012) describe the leaves as 'somewhat dimorphic; vegetative [non-gemmiferous] ones narrow and elongate, linear to lanceolate; gemmiferous ones shorter and broader, often deltoid and forming a terminal coma'. Leaf dimorphism is not mentioned by Eddy (1990). In the plant shown in Fig. 12 there is little difference between gemmiferous and non-gemmiferous leaves and no evidence of deltoid leaves. The intermittently bordered leaves and long filamentous gemmae borne on the costa (mostly around mid-lamina) are distinctive characters.

Selected specimens seen: Queensland: North Kennedy District; South of Tully, track to Cochable Creek camp site from Cardstone Road, *D.A.Meagher and A.Cairns WT-604B*, 25 May 2015, BRI AQ1019801.

13. *Syrrhopodon perarmatus* Broth. in Broth. & Watts, *J. Proc. Roy. Soc. New South Wales* 49: 133 (1915).

Original material: 'Santo: Bowie, 1909 (Hb. Watts, 89); Aneityum: Gunn, Oct., 1911 (Hb. Watts, 193, Hb. Lillie, 697), May-June, 1913 (Hb. Watts, 410); Futuna: Gunn, Oct. 1912 (Hb. Watts, 292).'

Type: (3 syntypes): (1) *Bowie s.n.*, not seen; (2) *Watts 193*, BM000672396!d; (3) *Gunn s.n.*, BM000672395!d, E00261323!d.

Note: We are uncertain whether a lectotype has been selected. BM000672395 is annotated by Len Ellis 'This is *Syrrhopodon tristichus*'. If that is correct, the protologue may have been based on more than one species, or *Watts 410* may be a mixed collection.

Illustration: Fig. 13.

Description: Plants medium-sized, dull green to brownish-olive, to 3 cm tall, forming loose to dense tufts. Stems stiffly erect to flexuose, simple or forked; rhizoids brown. Leaves spreading from an erect sheathing base, abruptly contracted at shoulder to an elongate linear, narrow parallel-sided limb, 6–10 mm long, 0.5 mm wide at shoulders; apex ± obtuse, serrate, margins of limb thickened, with strongly developed but largely concealed marginal stereomes exposed, if at all, only on adaxial side but mostly covered by lamina-like chlorophyllose cells many of which are produced into conical teeth; border densely and irregularly toothed throughout, continuing down each side of the sheathing base and at the shoulders long spinose-ciliate. Costa strong, in section with 4–6 guide cells, strongly developed adaxial and abaxial stereid bands, and a well-developed chlorophyllose and often conical-spinose epidermal layer. Cells of upper chlorophyllose lamina smooth, mainly rounded-hexagonal or ± circular, strongly biconvex, the adaxial and abaxial walls strongly thickened and lenticular. Hyaline lamina occupying almost entire sheath, tapering upwards and ending at base of limb at an acute angle. Gemmae not seen. Sporophytes with seta yellowish, about 6 mm long. Capsule about 1.5 mm long, cylindrical-ovoid, about 0.3–0.4 mm wide in middle; operculum bluntly conical, about 0.3 mm tall.

Etymology: Latin *perarmatus* (well-armed), referring to the strongly dentate-ciliate leaf margins.

Distribution: Known from Vanuatu, Malesia, Papua New Guinea and adjacent islands, Solomon Islands, Polynesia, and Fiji. *Syrrhopodon perarmatus* is presumed to be extinct in Australia, but might never have occurred there. It was reported from New South Wales from specimen in Mitten's herbarium in NY, which Reese and Stone (2012) attributed to Alexander Collie (1793–1835) and suggested it might be the result of a mislabelling. However, the collector is more likely to have been the Reverend Robert Collie (1839–1892), since

the specimen they cited is labelled 'Sydney, Bro. Collie' and Alexander Collie's Australian collections were all made in south-west Western Australia (AVH 2022; JSTOR Global Plants 2022).

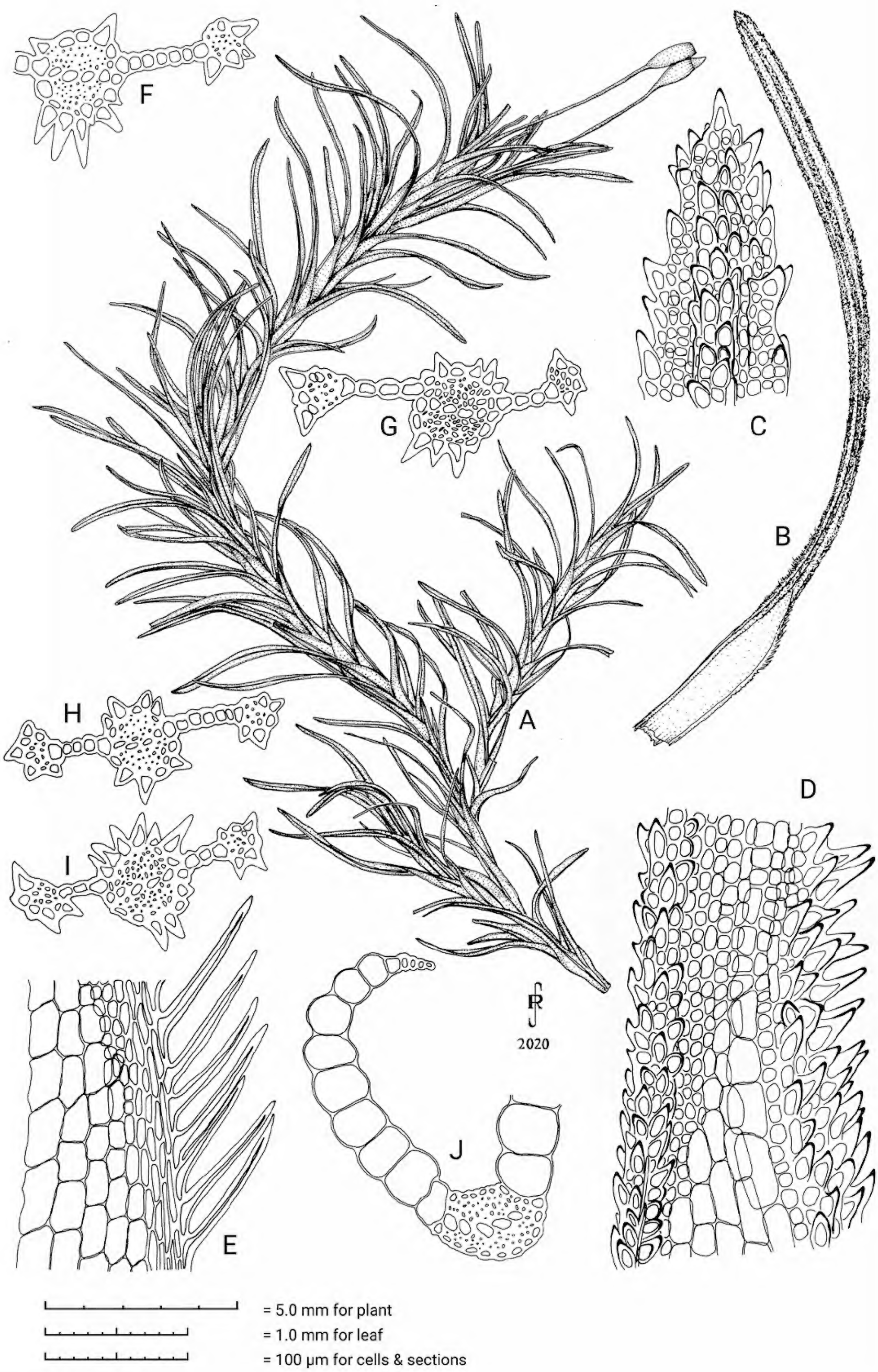


Fig. 13. *Syrrhopodon perarmatus* Broth & Watts. **A:** Habit of plant, drawn moist. **B:** Stem leaf. **C:** Cells of leaf apex, abaxial view. **D:** Cells of distal hyaline lamina from margin (left) to costa (right). **E:** Marginal ciliate spicules of leaf shoulder region. **F–I:** Sections of leaf limb. **J:** Section of sheathing leaf base. Drawn from *H.Streimann 62600*.

Robert Collie lived in Sydney from 1876 to 1892 and collected widely in New South Wales, including the subtropical north-east of the state. There are 14 of his bryophyte collections in Australian herbaria, and several more in overseas herbaria (AVH 2022; JSTOR Global Plants 2022). We are therefore inclined to accept the record as genuine, although noting the possibility of a mix-up of specimens or labels. Alternatively, the specimen may simply be misidentified.

Habitat: Trees and stumps in wet forests up to about 1200 m a.s.l.

Recognition: The description used here is based on Reese *et al.* (1986), Eddy (1990) and the specimen examined. It is noteworthy that the original description gives stems up to 7 cm long and leaves to 5 mm long. The illustrated specimen was collected from Vanuatu, where it formed large continuous colonies on a semi-shaded *Dysoxylum* trunk within tropical forest. Reese *et al.* (1986) noted the range of the species was eastern, from Papua New Guinea to Fiji, Solomon Islands, Vanuatu and reportedly from New South Wales. In Papua New Guinea and the Solomon Islands it grows on trees and stumps in wet forests to about 1000 m a.s.l. Eddy (1990) gave the distribution as 'widespread in tropical and temperate Australasia, extending northwards to Polynesia and just reaching Malesia in Papua New Guinea and adjacent islands'.

Syrrhopodon perarmatus superficially resembles a robust form of *S. spiculosus* but it is usually taller with longer leaf limbs. The comb-like spiculose margin of the leaf shoulders is more regularly arranged than in most forms of *S. spiculosus* and differs microscopically in the smooth chlorophyllose lamina cells, rather than coronate-papillose lamina cells as in the latter species.

Selected specimens seen: Vanuatu: Espiritu Santo Butmas; Mount Tanakar Plateau, 26 km north west of Luganville, *H.Streimann 62600*, 20 October 1998, CBG 9912195.1.

14. *Syrrhopodon platycerii* Mitt., *Fl. Vit.* 388 (1873).

Original material: 'Lord Howe's Island, on *Platycerium* (McGillivray and Milne! Herb. Hooker).'

Type: Australia: New South Wales, Lord Howe Island, *McGillivray & Milne 43*, 1853, isotypes BM000918844!d, BM000918845!d, MO406956!d, NY01127791!d , NY01127792!d, NY01127793!d.

Note: We are uncertain whether a lectotype has been selected. NY01127791 seems to be the best candidate, since it is from Hooker's herbarium and has Mitten's sketch in pencil. The collection number is taken from isosyntypes in BM and NY, and the date is when the *Herald* was at Lord Howe Island (David 1995).

Australian synonym: *Syrrhopodon novae-valisiae* Müll. Hal., *Hedwigia* 37: 119 (1898), *fide* Reese *et al.* (1986). **Original material:** 'Habitatio. Australia, New South Wales, Sydney: Domina Kayser in Hb. Geheeb, serius Herriott 1881 in Hb. Melbourne; Richmond River: Fawcett 1881 et Trinity Bay: Sayer 1886 in codem Hb., forma microscopica.' **Type:** Syntypes: Australia, New South Wales, (1) Sydney, *F.Kayser s.n.*1875 (date from isosyntypes); Sydney, *Herriott s.n.,* 1881; (2) Richmond River, *Fawcett s.n.*, 1881; (3) Queensland, Trinity Bay, *W.Sayer s.n.,* 1886; syntypes: B (destroyed), isosyntypes: (1) BM000672651!d, BM000672653!d, (2) JE04001452!d, JE04001453!d, JE04001454!d, (3), none seen.

Syrrhopodon novae-valisiae is often referred to incorrectly as *S. novae-valesiae*. The collector as annotated on the isosyntypes was Friedrich Kayser, although 'Domina Kayser' in the list of original material translates as 'Mrs Kayser'. We have not found isosyntypes in Australian herbaria, which is surprising because the Fawcett collection was distributed by Ferdinand von Mueller (ex MEL) and Sayer's collections are well-represented in MEL.

Illustrations: Fig. 14. Also Mitten in Seemann (1865: fig. 98j), Reese *et al.* (1986).

Description: Plants small, dark green, in soft low turfs and cushions, to 5 mm tall. Stems short, to 2 mm; rhizoids red. Leaves monomorphic, 2.0–3.5 mm long, short pointed from a broader base; when dry, leaves strongly helically twisted above shoulders, straight when moist; margins strongly bordered throughout with hyaline cells, toothed in upper 1/3–1/2 with well-separated teeth; costa 35–50 μm wide in mid leaf, ending in a short mucro; in section with mostly 2 median guide cells in upper leaf, with an additional enlarged hyaline cell either side in hyaline lamina, with small adaxial and larger abaxial stereid bands, epidermal layer not differentiated; cells of chlorophyllose lamina thick-walled, papillose on both surfaces with stout multifid papillae, chlorophyllose cells decurrent down margins of hyaline lamina; hyaline lamina large, conspicuous, scalariform distally. Gemmae scarce, clavate, borne adaxially along costa. Sporophytes with long-rostrate and cucullate calyptra. Seta yellow, about 5 mm long. Capsules cylindrical, 1.0–1.5 mm long; operculum slenderly long-rostrate. Peristome of low, imperfect transversely barred teeth. Spores about 16–18 μm in diameter, ± smooth.

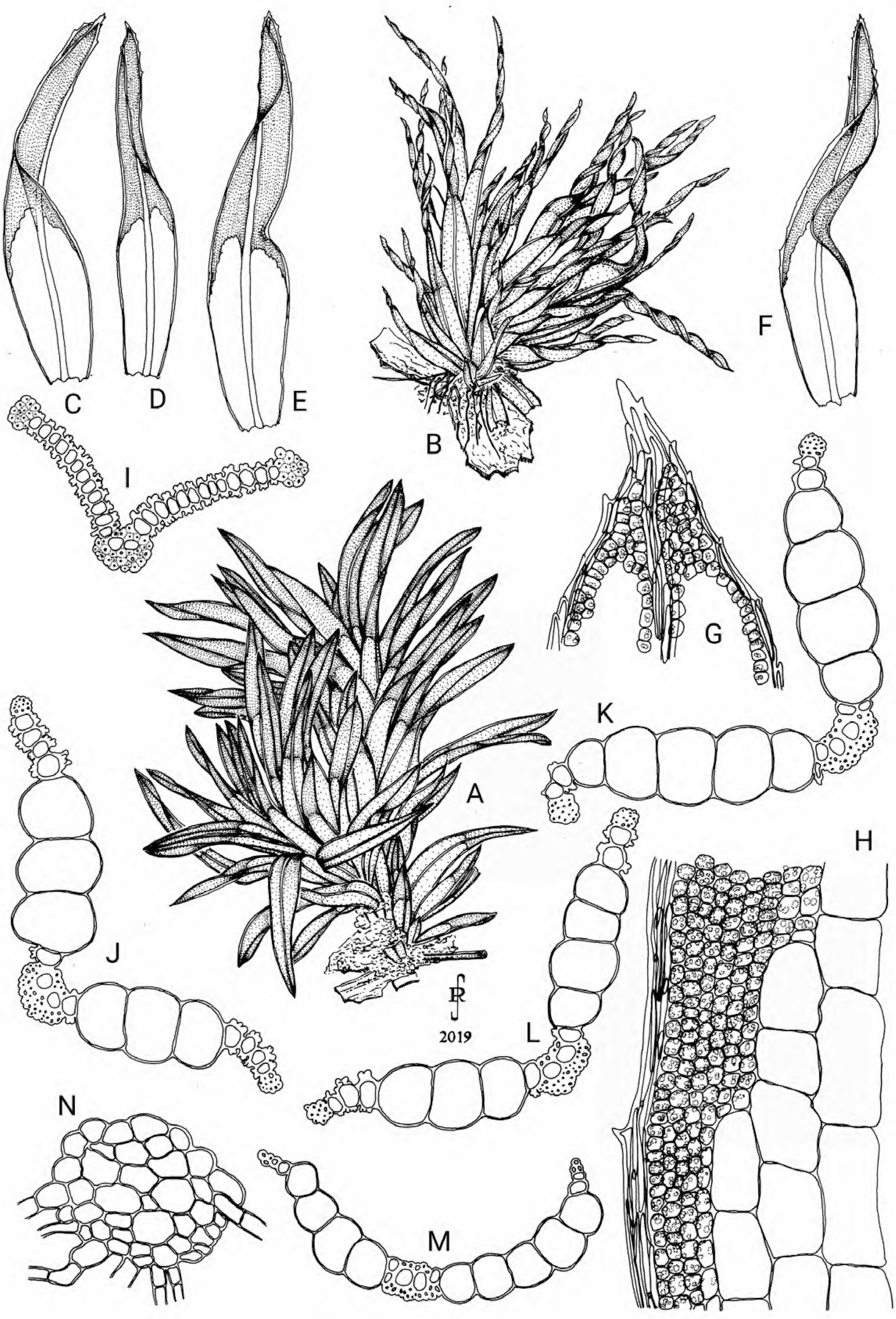


Fig. 14. *Syrrhopodon platycerii* Mitt. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C–F:** Leaves. **G:** Cells of leaf apex. **H:** Cells of distal hyaline lamina. **I:** Section of upper leaf limb. **J–M:** Sections of cancellinar region. **N:** Stem section. Drawn from *A.J.Franks AJF1406044B*.

Etymology: Referring to the fern genus *Platycerium* on which the species grows.

Distribution: Endemic to Australia, along the eastern coast of the Australian mainland, from the Windsor Tableland of Queensland to to Port Hacking, south of Sydney, and on Lord Howe Island (Fig. 21.14). Meagher (2002) reported it growing in cultivation on a living *Platycerium* fern in Melbourne, Victoria.

Recognition: When dry, the helically twisted leaf limbs are quite characteristic. It grows exclusivley on the bases of *Platycerium* ferns. Reese and Stone (2012) noted that colonies are commonly fertile, unusual for *Syrrhopodon*, but perigonia and antheridia have been elusive, and Rees *et al.* (1986) suggested that the species might be monoicous, based on dissections of fertile material. The specimen used for illustration was collected from the base of a fallen *Platycerium* fern in an upland complex notophyll vine forest.

Selected specimens seen: Queensland: South Kennedy District: Wishing Pool Circuit, Eungella National Park, about 11 km south of Eungella Village, 776 m a.s.l. *A.J.Franks AJF1406044B*, 30 June 2014, BRI AQ0910164. New South Wales: East Ballina, *W.W.Watts NSW 5531*, 31 Mar 1902, NSW 752844!; Lord Howe Island, behind Johnson's, *W.W.Watts LHI 114*, 8 July 1911, NSW 752803!.

15. *Syrrhopodon prolifer* Schwägr. **var. *prolifer*** *Spec. Musc. Suppl.* 2(2): 99, pl. 180 (1827).

Original material: 'Ad terram in umbrosis ad pedes montium Sierra dos Orgos in Brasilia legit dilig. Beyrich.'

Type: Brazil: Rio de Janeiro state, at the foot of the Serra dos Órgãos, *H.K.Beyrich s.n.,* 1823; lectotype (designated by Ellis 2011): G 00042872[a], not seen; isolectotypes: G 00040509 not seen, G 00040510 not seen, BM000664154!d (all *fide* Ellis 2011), GOET013644!d.

Illustrations: Fig. 15. Also Schwägrichen (1827: t. CLXXX), Ellis (1985: 13), Reese and Lin (1991: 349), Ellis and Tan (1999: 44), Ellis (2003: 167).

Note: The illustration in Schwägrichen is in table CLXXX, not CLXXXI as stated in the protologue. The date of collection is from an annotation on the packet of the material in GOET.

Description: Plants to 3 cm tall, usually shorter, pale green to olive green, forming loose tufts. Stems erect, simple or forked; rhizoids red to brownish, often copious among the lower leaves. Leaves straight, closely set, straight or variously contorted when dry, erect spreading when moist, narrowly lanceolate, the sheathing base little wider than the limb, 2–5 mm long, about 0.3 mm wide in limb, limb linear to linear-acuminate, apex more or less truncate, rarely acute; bordered all round with a pellucid, multicellular stereome; margins entire except at leaf tip; stereome running down margins of leaf shoulders and into sheathing base. Costa pellucid, smooth almost throughout its length, in section with 2(–4) guide cells, adaxial and abaxial stereid bands, epidermis differentiated in part adaxially in upper limb, lacking abaxially. Cells of chlorophyllose lamina pluripapillose with low papillae on both surfaces, the cells thick-walled with a rounded lumen, 6–8 μm wide. Hyaline lamina occupying almost entire sheathing base, narrowing gradually distally; cells of chlorophyllose lamina decurrent down margins for some distance, not decurrent down costa. Gemmae uncommon, clavate, borne adaxially on leaf tips. Sporophytes not seen in Australian material.

Etymology: Latin *prolifer* (fruitful), presumably referring to the abundant capsules in the type material.

Distribution: North-eastern Queensland, on Thornton Peak and the Bellenden Ker Range (Fig. 21.15). Elsewhere pantropical, occurring in Mexico, South and Central America, Caribbean islands, tropical Africa, Madagascar, Mauritius, Réunion, Seychelles, tropical Asia, India, Sri Lanka, Malesia, Papua New Guinea and Hawaii.

Habitat: On tree trunks and roots.

Recognition: *Syrrhopodon prolifer* is also similar to *S. trachyphyllus*, but in that species the leaves are often incompletely bordered and are usually toothed at the shoulders. It is also similar to *S. muelleri*, but that has the leaves stiffly erect, the plants have a ± stemless habit, and the cells of the chlorophyllose lamina are mostly finely papillose. Orbán and Reese (1990) reviewed the distribution and variation within the *S. prolifer* complex on a worldwide basis.

Reese (1989) and Reese and Stone (2012) recognised *S. prolifer* var. *mossmanensis* W.D.Reese & I.G.Stone, from northern Queensland. However, Ellis (2003) demonstrated that this variety was a synonym of *S. katemensis*, which has much smaller leaves and stout and conspicuous multifid papillae on the cells of the chlorophyllose lamina.

Selected specimens seen: Queensland: Cook District; Bellenden Ker Range, route between Centre Peak and North Peak, *D.A.Meagher and A.Cairns, WT-1120A*, 17 August 2016, BRI AQ1020915.

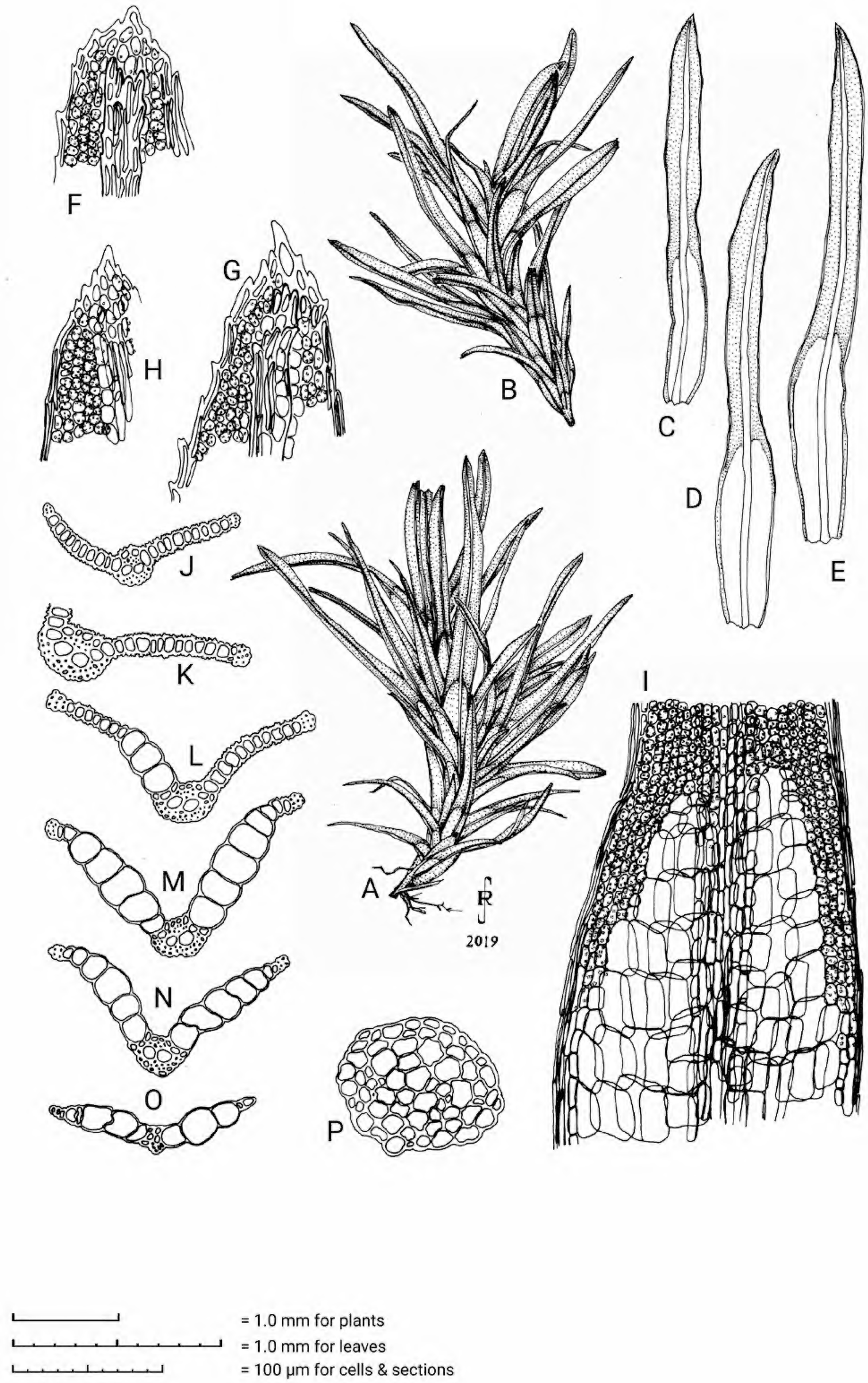


Fig. 15. *Syrrhopodon prolifer* Schwägr. var. *prolifer*. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C–E:** Stem leaves. **F, G:** Cells of leaf apex, abaxial view. **H:** Cells of leaf apex, adaxial view. **I:** Cells of hyaline lamina. **J, K:** Sections of leaf limb. **L:** Section of distal end of hyaline lamina and base of limb. **M–O:** Sections of sheathing base of leaf. **P:** Stem section. Drawn from *D.A.Meagher and A.Cairns, WT-1120A*.

16. *Syrrhopodon semperi* Müll.Hal., *Linnaea* 38: 557 (1874).

Original material: 'Patria. Insulae Philippinae, Luzon, reg. tropica: Dr. Semper 1861.'

Note: The isotype is from herb. Hampe.

Type: Philippines: Luzon, *C.Semper s.n.*, 1861; holotype: B (destroyed); isotype: BM-000675254!d.

Illustrations: Fig. 16. Ellis (2003: 170).

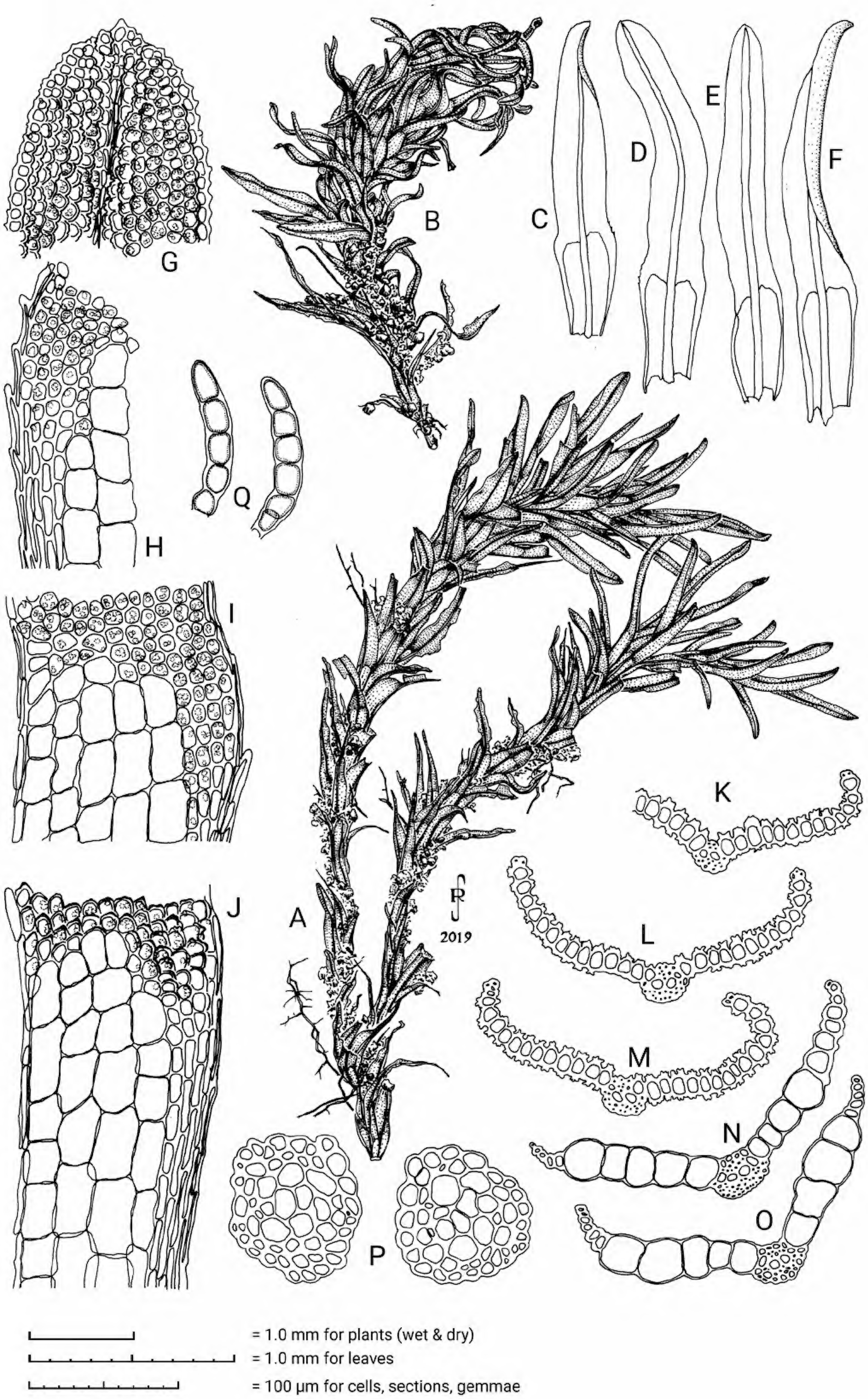


Fig. 16. *Syrrhopodon semperi* Müll.Hal. **A:** Habit of plant, drawn moist. **B:** Habit of plant, drawn dry. **C–F:** Leaves. **G:** Cells of leaf apex, adaxial view. **H, I:** Cells of distal hyaline lamina. **J:** Cells of proximal hyaline lamina. **K–M:** Sections of leaf limb. **N, O:** Sections of sheathing base of leaf. **P:** Stem section. **Q:** Gemmae. Drawn from *M.A.M.Renner 8635*.

Description: Plants small, dark green to brownish green or rusty green, forming low tufts or turfs. Stems simple or occasionally forked, 6–10 mm tall; rhizoids red. Leaves small, oblong to ligulate from a slightly broader base, 1.5–2.5 mm long, about 0.25 mm wide in limb, 0.35 mm wide at leaf shoulders; involute and uncinate to curled when dry, straight to slightly incurved when moist; limb ligulate, with a broadly acute to obtuse apex and margins typically involute to inrolled; border relatively weak, 2–3 cells wide, 1–2 cells thick, distinct but often concealed by incurved margins of limb, usually with distant teeth or cilia but sometimes these are low or lacking, the border disappearing some distance below leaf apex, usually distinctly toothed or ciliate at shoulders; costa variable, mostly smooth, pellucid, in section with 2–4 guide cells, adaxial and abaxial stereid bands, epidermal layer not developed or epidermal cells conical-mammillate; cells of chlorophyllose lamina papillose with multifid or coronate papillae, thick-walled, rounded-quadrate, 6–10 μm wide; hyaline lamina of relatively few rows of cells, rounded distally or weakly scalariform, bordered marginally by elongate cells of leaf border. Gemmae small, few, cylindrical clavate, borne adaxially near leaf tip. Sporophytes occasional; calyptra about 1.2 mm long; seta red, 3–4 mm long; capsules brown, obliquely ovoid, about 1 mm long; operculum slenderly rostrate, about 0.5 mm long. Peristome teeth yellowish, slender, imperfect, fragile, papillose, ± jointed, 48–72 μm long. Spores 9–10 μm in diameter, smooth.

Etymology: After German zoologist Carl Semper (1832–1893), who collected the type.

Distribution: Known from Daly River and Katherine Gorge in northern Northern Territory, and in north-eastern Queensland from Cape Tribulation south to the Paluma Range (Fig. 21.16). Also widespread around coastal tropical Asia from India to Cambodia and southern Japan, and the Malay Peninsula, Borneo, Philippines, Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia and the Pacific islands.

Habitat: Tree bases, roots, rock and soil from sea level to about 500 m a.s.l., typically in mesophyll vine forest and often in rather open sites.

Recognition: A rather variable species with a wide distribution which is similar to the less spiculose forms of *S. spiculosus*, but distinguished by its adaxially smooth or papillose, not spiculose costa which, close to the apex, tends to be ± hidden below the general adaxial leaf surface. Ellis (2003) states for *S. semperi*: 'It has ligulate leaves, <2–2.5(–3) mm long. The costa ends immediately short of the leaf apex and has a smooth surface formed by stereids, completely lacking spines or multifid projections. The chlorophyllose lamina is inflexed and composed of cells with similar dimensions and structure to those of *S. trachyphyllus*'. The specimen used for illustrating *S. semperi* was collected from logs on a stream bank in notophyll forest, occurring with *Acanthorrhynchium papillatum* (Sematophyllaceae). The specimen was initially determined as *S. trachyphyllus* but the identify was revised to *S. semperi* by Ellis (L.T.Ellis pers. comm., 17 July 2020).

Selected specimens seen: Queensland: Cook District: Daintree River National Park, trail to summit of Thornton Peak, camp site at Hilda Creek at base of mountain, 161 m a.s.l., *M.A.M.Renner 8635*, 18 August 2017, NSW1061163.

17. *Syrrhopodon spiculosus* Hook. & Grev., *Edinburgh J. Sci.* 3: 326 (1825).

Original material: 'Hab. Sincapore, Dr Wallich.'

Type: Singapore, *s.loc., N.Wallich s.n.*, 1822; isotypes BM000664503!d, BM000664504!d, BM000664506!d, BM000664510!d, E00256126!d, K001127484!d (lost).

Note: K001127484 is annotated 'missing 2/iii/54' and has no specimen in the folder. The collection date is taken from an annotation on the isotype folder in K.

Illustrations: Fig. 17. Also Reese and Lin (1991: 358), Ellis and Tan (1999: 41).

Description: Plants in loose tufts, to 4 cm or taller, olive green to brownish. Stems erect; rhizoids red. Leaves little altered wet or dry, the limb linear to narrowly linear from an erect, colourless sheathing base, erect-spreading to patent, 2.5–4.0 mm long, about 0.25 mm wide in leaf base, 0.15–0.20 mm wide in mid limb; margins of upper limb typically ± involute, minutely hispid; narrowly bordered below, reduced in upper limb or absent, often obscured by involute margins, border of leaf shoulder usually with spines or cilia of varying length, sometimes sparse or absent; leaves sometimes with tufts of rhizoids arising from adaxial surface of leaf tip. Costa strong, about 50 μm wide in limb, ending just below leaf apex, hispid on both adaxial and abaxial surfaces in limb with spines or acute-conical projections; in section with 2–5 guide cells, thick adaxial and abaxial stereid bands and distinct epidermal layer. Cells of chlorophyllose lamina thick-walled, quadrate to short rectangular, 5–11 μm wide, usually obscured by the tall, sometimes compound, coronate papillae on both surfaces, often with some cells having lower simple papillae; hyaline lamina sharply delimited, occupying almost entire leaf sheath, ± scalariform, ending at a narrow acute angle to the costa and penetrating quite high

into base of limb, bordered by a narrow band of 3–4 rows of thick-walled elongate cells. Gemmae uncommon, clavate or fusiform, borne adaxially at tip of costa. Sporophytes not seen in Australian material.

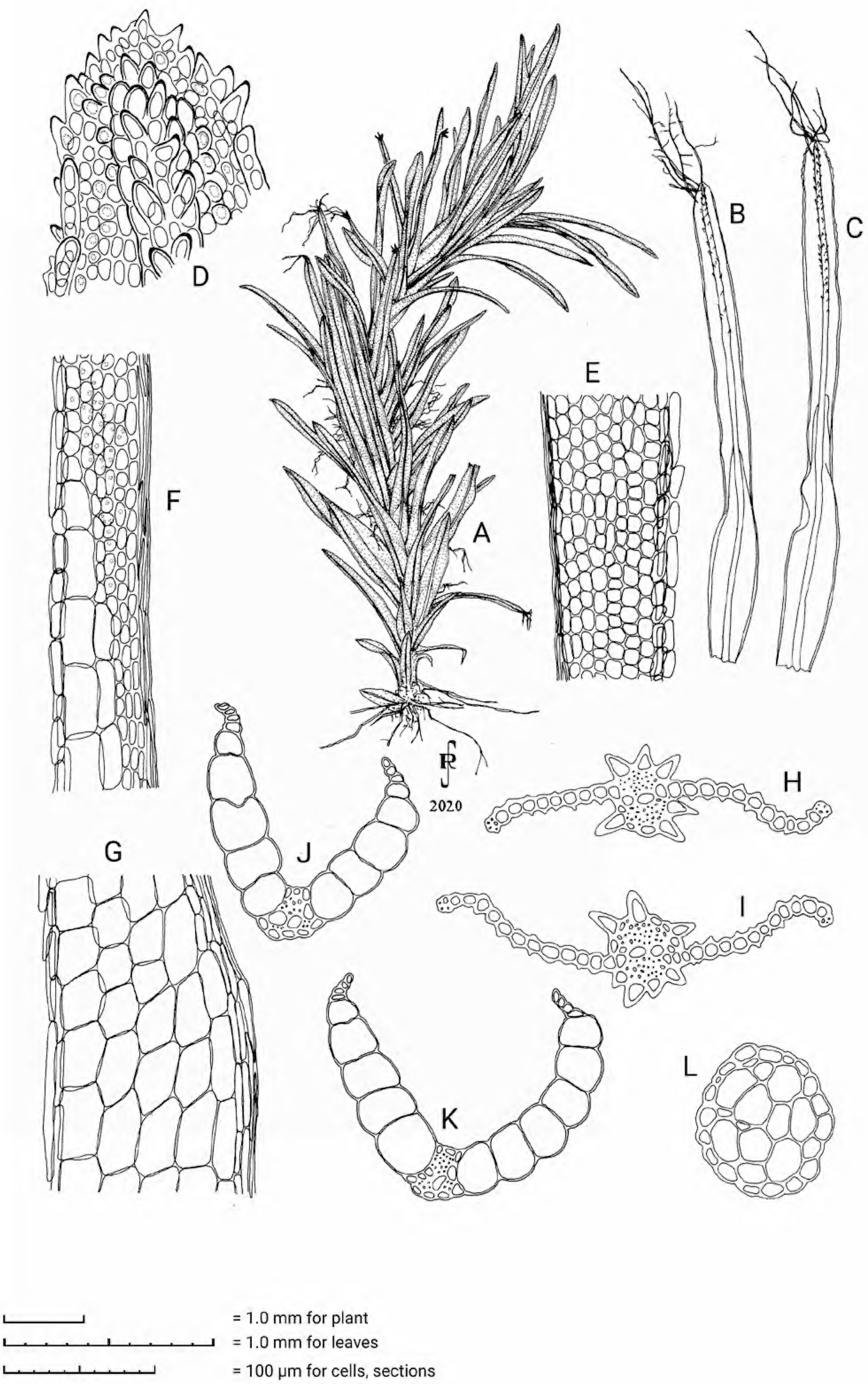


Fig. 17. *Syrrhopodon spiculosus* Hook. & Grev. **A:** Habit of plant, drawn moist. **B, C:** Leaves with terminal clusters of rhizoids, abaxial view. **D:** Leaf apex, abaxial view. **E:** Cells of leaf limb, mid leaf region, abaxial view. **F:** Cells at distal end of hyaline lamina, from costa (left) to margin (right). **G:** Cells of hyaline lamina, from costa (left) to margin (right). **H, I:** Leaf sections of distal part of limb. **J, K:** Sections of sheathing leaf base. **L:** Stem section. Drawn from *D.Lucas 114*.

Etymology: Latin *spiculosus* (covered in small sharp points), referring to the 'pellucid denticulated or spiculated unequal processes' on the leaf margins and on the costa.

Distribution: Northern Territory: Arnhem Land and Melville Island south to Katherine Gorge (Fig. 21.17). Also tropical Asia from India, Sri Lanka, Thailand, throughout Malesia and Polynesia.

Habitat: On shaded rock faces, and sometimes on bark and soil, in monsoon forest, and in protected gorges in seepage areas on shaded rock faces, generally below 300 m a.s.l.

Recognition: Australian material of *S. spiculosus* is somewhat enigmatic because nearly all the specimens seen by Bill Reese have an appended annotation by him referring to the rarity or absence of the marginal spicules. Such forms may be confused with *S. albovaginatus* as both species have spreading-patent leaves when moist or dry, with the latter species also having entire leaf shoulders, as in the specimen of *S. spiculosus* illustrated here. However, the leaf lamina cells of *S. spiculosus* have multifid papillae while those of *S. albovaginatus* are simple. Further, the limbs of leaves of *S. spiculosus* lack the obliquely transverse rows of conical-dentate cells seen in *S. albovaginatus*. *Syrrhopodon spiculosus* is a highly variable taxon, as evidenced by a long list of synonyms. Eddy (1990) summed up the variability: 'The marginal stereome may be almost entire at times, the cilia or teeth of the leaf shoulders may be reduced to low, remote teeth and the lamina cell papillae may be small and less profusely coronate.'

Selected specimen seen: Northern Territory: Kakadu; Steep Boulder Gorge, 80 m a.s.l., *D.Lucas 114*, 16 June 1988 (CBG 8803892).

18. *Syrrhopodon stoneae* W.D.Reese, *Bryologist* 92: 302, fig. 1–3 (1989).

Original material: 'Australia. Queensland. Trail up Mt Bartle Frere from Josephine Falls; tropical rainforest; 17°26'S, 145°52'E; fallen tree trunk, *W. B. Schofield & M. I. Schofield 79707* (holotype — UBC, isotypes — LAF, MELU, NSW). Paratype: As above; on fallen tree trunk by stream, *W. B. Schofield & M. I. Schofield 79652* (LAF, MELU, NSW, UBC).'

Type: Australia: Queensland, Josephine Falls, Bartle Frere track, *W.B.Schofield & M.I.Schofield 79707* 25 July 1983; holotype: UBC, not seen; isotypes: LAF, not seen, MELU!, NSW, not seen. Paratype: MELUB3163.

Illustrations: Fig. 18. Also Mohamed and Reese (1992: 89).

Description: Plants dark brownish green to blackish green. Stems 6–8 mm tall; rhizoids dark red. Leaves ± dimorphic, lanceolate, the sheathing base no wider than the limb, vegetative leaves few, 2.5–4.0 mm long, 0.4–0.5 mm wide at mid limb, leaves stiffly secund and involute when dry, stiffly erect spreading when moist; leaf limb narrowing at tip to a broadly acute to obtuse apex; most leaves gemmiferous, larger, to 5 mm long, the apex shortly proboscid; margins thickened in mid limb, denticulate above, entire or slightly serrulate below; costa strong, with 4–6 guide cells, strong adaxial and abaxial stereid bands, a differentiated epidermal layer, the epidermal cells conical mammillose above, becoming ± smooth in lower limb and sheathing base. Cells of chlorophyllose lamina thick-walled, ± quadrate to short rectangular, 10–12 μm long, adaxially conical mammillose-papillose, abaxially minutely uni- to pluripapillose; hyaline lamina sometimes indistinct, distally not sharply demarcated from chlorophyllose cells of limb. Gemmae clavate, borne adaxially on tips of gemmiferous leaves. Sporophytes unknown.

Etymology: After Australian bryologist Ilma Grace Stone (1913–2001).

Distribution: Known in Australia only from the type locality in north-eastern Queensland (Fig. 21.18). Also reported from Malaysia by Mohamed and Reese (1992), which suggests that it might be more widespread.

Recognition: *Syrrhopodon stoneae* is characterised by its dimorphic leaves, red rhizoids, thickened denticulate leaf margins, rather indistinct hyaline lamina, and absence of elongate hyaline marginal cells. Reese and Stone (2012) note that *S. stoneae* may be better placed in *Calymperes* than in *Syrrhopodon*. However, red rhizoids are rare in *Calymperes* but common in *Syrrhopodon*.

Selected specimen seen: Queensland: Bartle Frere, Josephine Falls. *W.B.Schofield 79652 and M.I.Schofield*, 25 June 1983 (MELU B3163), paratype.

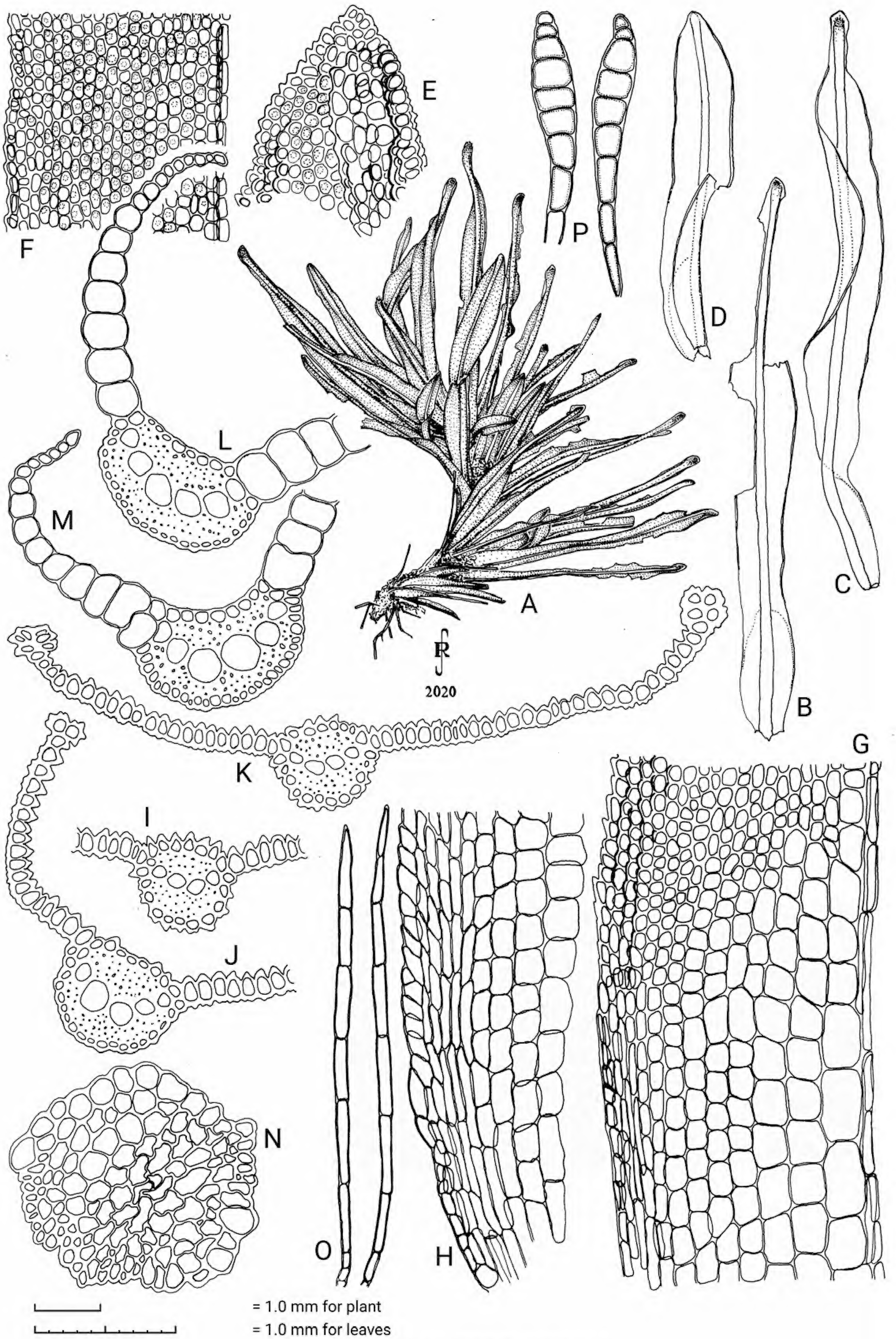


Fig. 18. *Syrrhopodon stoneae* W.D.Reese. **A:** Habit of plant, drawn moist. **B, C:** Gemmiferous leaves. **D:** Non-gemmiferous leaf. **E:** Cells of leaf apex, abaxial view. **F:** Cells of chlorophyllose lamina at mid limb, from margin (left) to costa (right). **G:** Cells from hyaline lamina. **H:** Cells from lower part of sheathing base of leaf, **I–K:** Sections of costa and lamina of limb. **L, M:** Sections of sheathing base of leaf. **N:** Stem section. **O:** Axillary hairs. **P:** Gemmae. Drawn from *W.B.Schofield 79652 and M.I.Schofield*.

19. *Syrrhopodon trachyphyllus* Mont., *Syll. Gen. Sp. Crypt*. 47 (1856).

Original material: 'Hab. In Singapour: cel. Gaudichaud.'

Type: Singapore, s. loc., *C.Gaudichaud-Beaupré s.n.*, c. 1837; isotypes: BM000672851!d, BM000675255!d, BM000675256!d, BM000866982!d, NY01127882!d, PC0130987!d, PC0130988!d.

Note: The collection date cited above is the year in which Gaudichaud visited Singapore.

Illustrations: Fig. 19. Also Eddy (1990: 75, as *S. semperi*), Ellis (2003: 162).

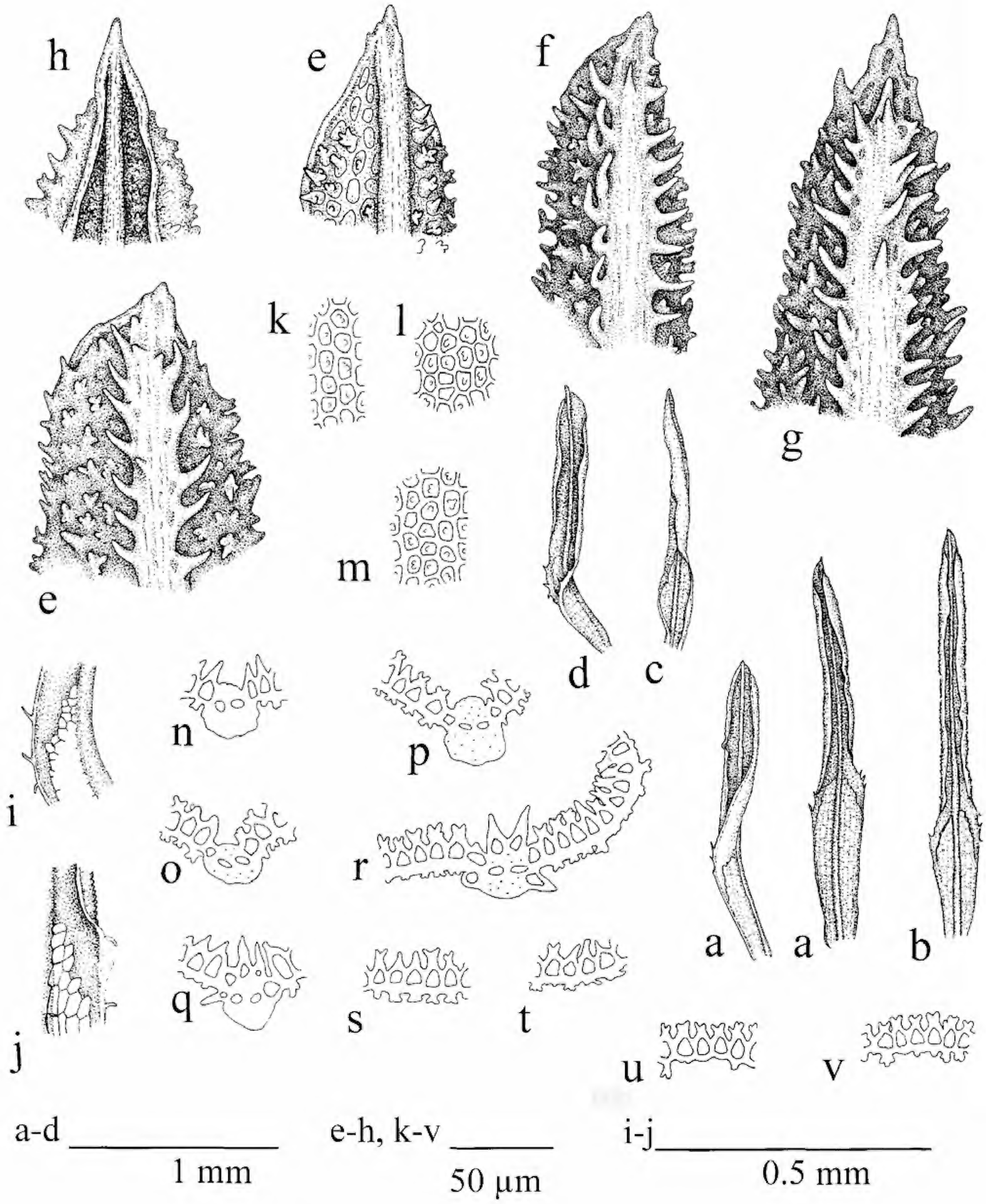


Fig. 19. *Syrrhopodon trachyphyllus*. Mont. **A–D:** Leaf in ventral view. **E–G:** Leaf apex in dorsal view. **H:** Leaf apex in ventral view. **I, J:** Distal hyaline lamina showing marginal spines. **K–M:** Chlorpohyllose lamia in surface view. **N–V:** cross-sections of leaf (n–r: costa; s–v: chlorophyllose lamina). a, e. h. k. o. r, v drawn from *Gaudichaud s.n.*, Singapore (BM); b, g, j, n, q, s drawn from *Binstead 30*, Sabah (BM); c, f, m, u drawn from *Griffith s.n.*, Singapore (BM); d, i, l, p, t drawn from *Milne s.n.*, Polynesia (BM). © Trustees of The Natural History Museum, London. Reproduced from Ellis (2003, Fig. 1) with permission.

Description: Plants small, dark green to brownish or rusty green, forming low tufts or turfs. Stems simple or occasionally forked, to 10 mm tall; rhizoids reddish. Leaves small, < 2.5 mm long, about 0.25 mm wide in limb, about 0.3 mm wide at shoulders, involute to uncinate when dry, straight to slightly curved when moist, limb ligulate, apex broadly acute to obtuse, margins typically incurved when moist; border relatively weak, 2–3 cells wide, 1–2 cells thick, often concealed by incurved margins of limb, at shoulders 1–3 cells wide,

unistratose, with or without distant teeth, spines or cilia. Cells of chlorophyllose lamina mostly rectangular to hexagonal or rounded, (6–)7.5–15(–17.5) × (6–)7.5–12.5 μm, papillose with multifid or coronate papillae or often with spinose surface projections. Costa variable, in section mostly more or less smooth, with 2–4 medial guide cells, adaxial and abaxial stereid bands, epidermal layer not developed or adaxially conical-mammillate. Hyaline lamina in relatively few rows, ending at a broad angle to the costa at about shoulder level. Sporophytes occasional. Calyptra about 1.2 mm long; seta reddish, 3–4 mm long; capsules brown, obliquely ovoid, about 1 mm long; operculum slenderly rostrate, about 0.5 mm long. Peristome teeth yellowish, slender, imperfect, fragile, papillose, ± jointed, 48–72 μm long. Spores 9–10 μm diameter, smooth.

Etymology: Greek *trachys* (rough) + *phyllon* (leaf), referring to the papillose leaf surface.

Distribution: Known from two locations in the northern Northern Territory, and in north-east Queensland from Cape Tribulation to Paluma (Fig. 21.19). Elsewhere, ranges from Sri Lanka through Singapore and the South East Asian archipelago to New Caledonia.

Habitat: Epiphytic, usually on tree trunks, from sea level to about 1000 m a.s.l., typically in mesophyll vine forest but often in drier and more open sites.

Recognition: The leaves of *Syrrhopodon trachyphyllus* differ from those of *S. semperi* principally in bearing dorsal-lateral costal spines, spines (rather than small teeth) along the leaf margin, and a continuous marginal stereome that reaches to the leaf apex (Ellis 2003).

Syrrhopodon trachyphyllus is also similar to the less spiculose forms of *S. spiculosus*, but distinguished by its adaxially smooth or papillose, not spiculose costa which, close to the apex, tends to be ± hidden below the general adaxial leaf surface. Other Australian species that might be confused with *S. trachyphyllus* are *S. armatus*, *S. katemensis* and *S. prolifer*.

According to Mohamed and Reese (1985), *Syrrhopodon semperi* Müll.Hal., *S. richardsii* Dixon and *S. lillei* Broth. are synonyms of *S. trachyphyllus*. However, Ellis (2003) studied the type specimens of these species, as well as those of *S. cambodiensis* Tixier and *S. flammeonervis* subsp. *lillei* (Broth.) Tixier, and concluded that they all belong to *S. semperi* (the earliest available name for the cohort) and that *S. trachyphyllus* is a distinct taxon. He also considered that the descriptions and illustrations of *S. trachyphyllus* in Reese and Lin (1991), Reese and Stone (1995) and Ellis and Tan (1999) are referrable to *S. semperi*.

Selected specimen seen: Queensland: Hilda Creek at track to Thornton Peak, *M.A.M.Renner 8635*, 18 Aug 2017, NSW 1061163.

20. *Syrrhopodon tristichus* Nees ex Schwägr., *Spec. Musc. Suppl.* 4: 316b (1842).

Original material: 'In Java lectum misit Nees von Esenbeck, praeses soc. Leopold.'

Type: Indonesia: Java, *s.loc., s.coll., s.d.*; lectotype (designated by Ellis 2011): G 00042992, not seen; isolectypes (*fide* Ellis 2011): BM000676720!d, BM000676721, not seen, BM000676723!d, BM000676725!d, ?G 00057757, not seen.

Note: The type citation merely indicates that Nees sent the specimen to Schwägrichen; Nees never travelled outside Europe. The date is taken from BM-000676723, which is annotated 'Java. Dr Greville 1832'. However, Greville never travelled outside Britain. It is possible that the collector was Nathan Wallich, who supplied many specimens to Greville and Hooker, and no doubt corresponded with Nees.

Illustrations: Fig. 20. Also Eddy (1990: 79, 80); Mohamed and Reese (1985: 230).

Description: Plants slender, to 6 cm or taller, pale green to yellowish or brown, forming loose tufts. Stems branching occasionally, erect to inclined or decumbent; rhizoids red to reddish brown. Leaves intermittently tristichous, closely imbricate, from a visible and conspicuous sheathing base abruptly recurved patent, little altered wet or dry, 5–8 mm long, slenderly long-acuminate from a broader base; sheathing base 0.35–0.40 mm wide, 0.20–0.25 mm wide in mid limb; leaf margins conspicuously bordered with a pellucid marginal stereome that is naked and entire in the sheathing base and base of limb, spinose-dentate in upper limb and there almost covered by a layer of short, pellucid or chlorophyllose cells; border reaching leaf apex or ending some distance below; costa about 35–60 μm wide in mid limb, smooth in lower leaf, usually dentate in acumen, in section ± plane adaxially, strongly convex abaxially, with 5–6 small guide cells, adaxial and abaxial stereid bands and an epidermal layer of thick-walled pellucid cells. Cells of chlorophyllose lamina thick-walled, rounded quadrate to short rectangular, about 7–11 μm wide, varying from ± smooth to densely pluripapillose. Hyaline lamina sharply delimited, mostly rounded distally, ± scalariform, cells of chlorophyllose lamina shortly decurrent down margins. Gemmae sparse, short clavate, ± rugose, borne adaxially and abaxially on leaf tips. Sporophytes not seen in Australian material.

Etymology: Greek *tristichos* (in three rows), referring to the three-ranked leaves.

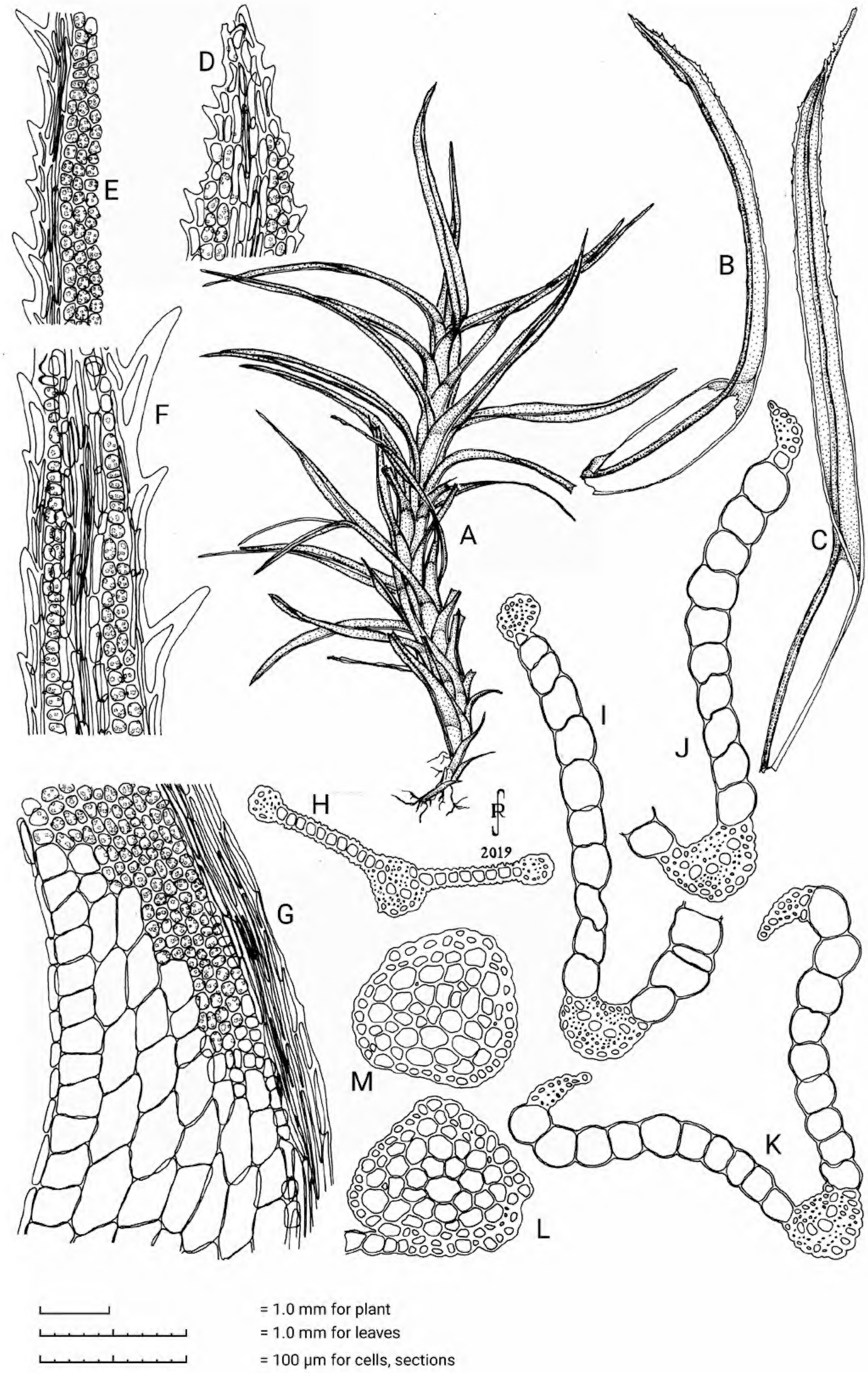


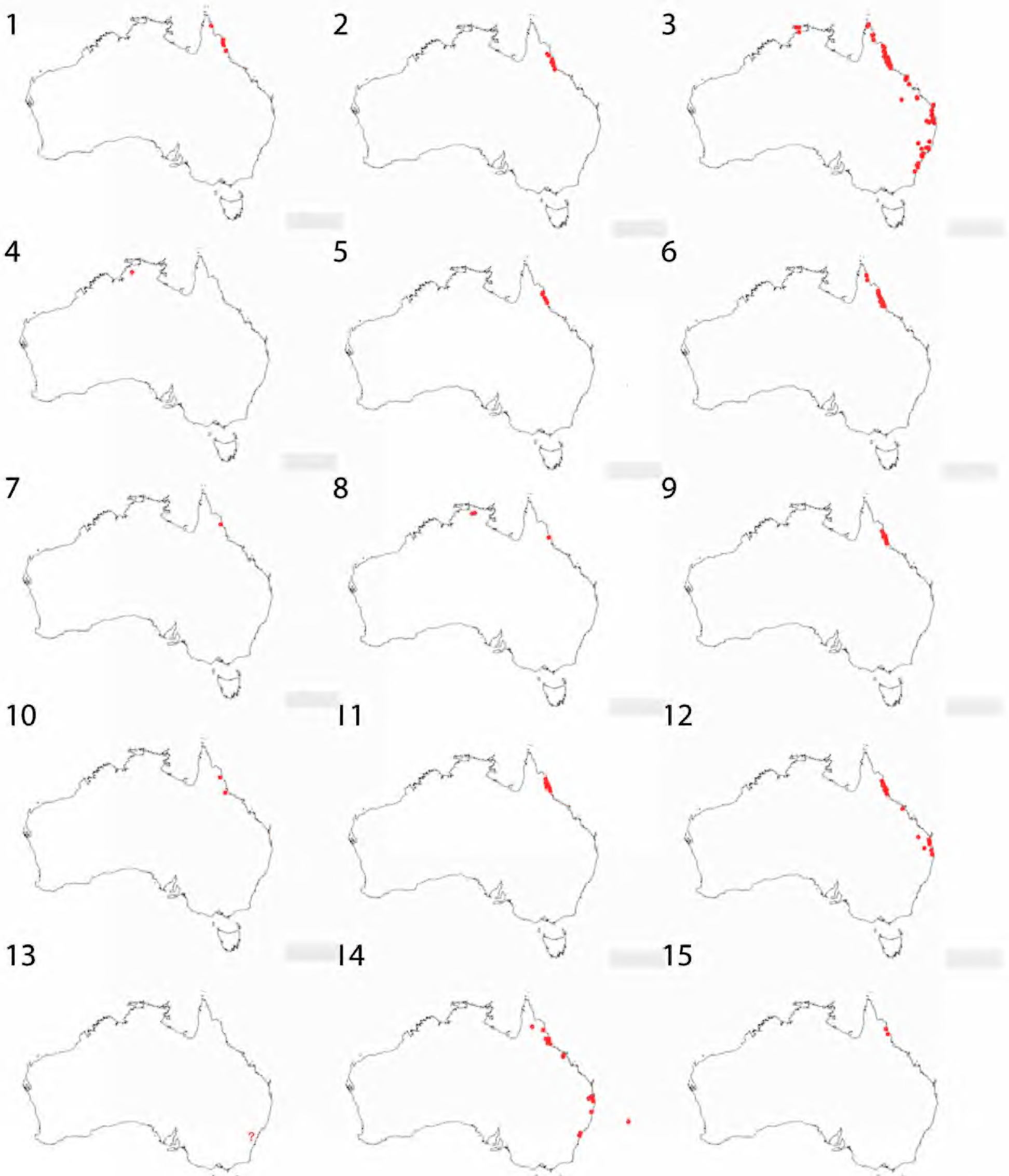
Fig. 20. *Syrrhopodon tristichus* Nees ex Schwägr. **A:** Habit of plant, drawn moist. **B, C:** Stem leaves. **D:** Cells of leaf apex, adaxial view. **E:** Cells of upper leaf margin. **F:** Cells of upper leaf limb, abaxial view. **G:** Cells of distal hyaline lamina. **H:** Section of leaf limb. **I–K:** Sections of sheathing leaf base. **L, M:** Stem sections. Drawn from: *M.A.M.Renner 8432*.

Distribution: High peaks (Bellenden Ker, Thornton Peak, Mount Lewis) in north-eastern Queensland (Fig. 21.20). Widely distributed in tropical Asia from India, Sri Lanka to Malesia, Philippines, Moluccas, Papua New Guinea, Polynesia, Oceania.

Habitat: Grows on trunks of small to medium sized trees in elfin cloud forest.

Recgnition: The species can be distinguished by its large size, the ± tristichous leaf arrangement, widely reflexed leaf limbs, gradually tapering narrow leaves, and sharply defined hyaline lamina.

Selected specimens seen: Queensland: Daintree River National Park, Thornton Peak, summit forest complex, *M.A.M.Renner 8432*, 14 August, 2017, NSW 1060783; Mt Finnigan, *M.A.M.Renner 8145*, 7 June 2017, NSW 1060627.



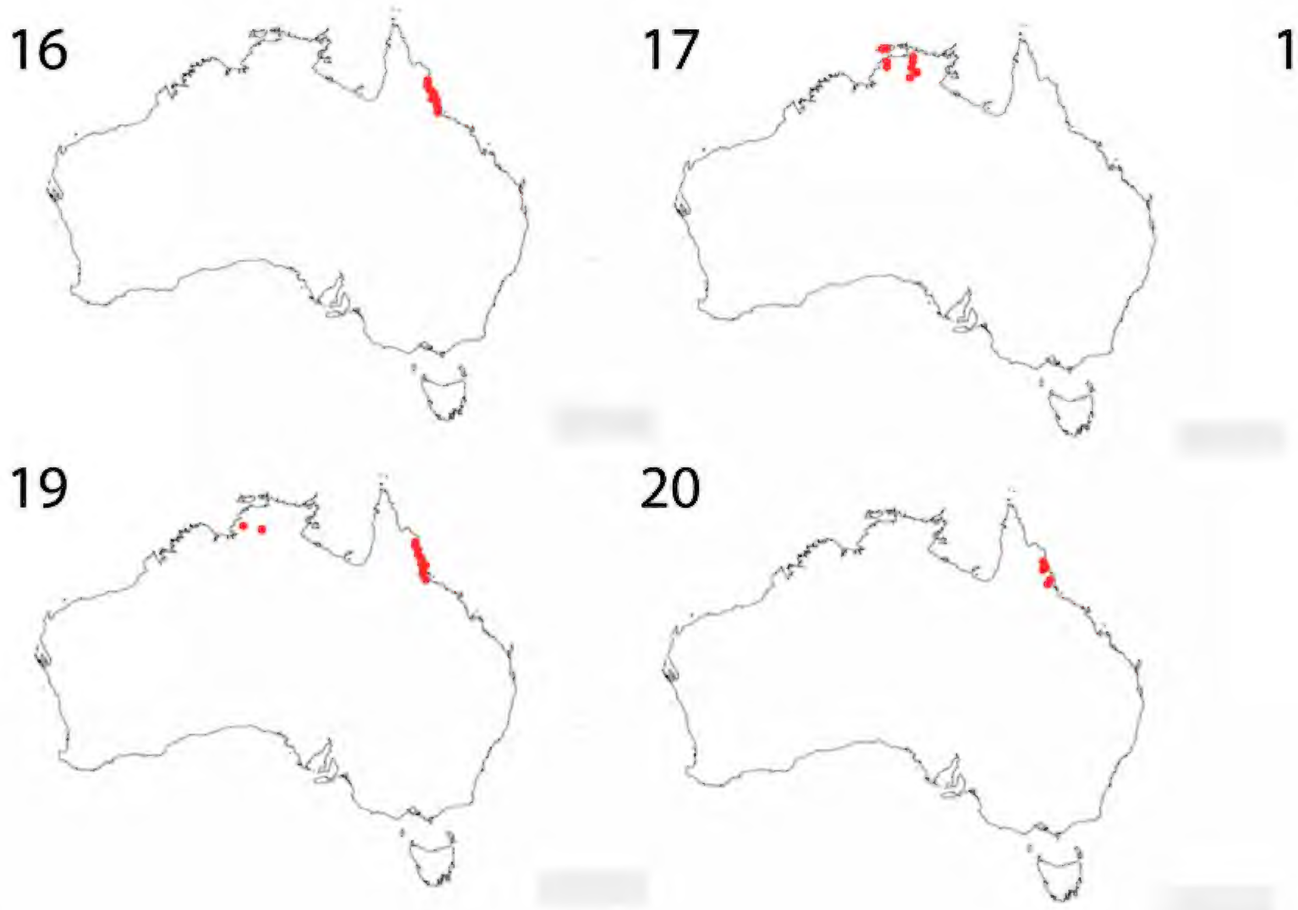


Fig. 21. Distribution of *Syrrhopodon* species in Australia. **1** *Syrrhopodon albovaginatus*. **2** *Syrrhopodon aristifolius*. **3** *Syrrhopodon armatus*. **4** *Syrrhopocon ciliatus*. **5** *Syrrhopodon confertus*. **6** *Syrrhopodon croceus*. **7** *Syrrhopodon cyrtacanthos*. **8** *Syrrhopodon gardneri*. **9** *Syrrhopodon involutus*. **10** *Syrrhopodon katemensis*. **11** *Syrrhopodon muelleri*. **12** *Syrrhopodon parasiticus*. **13** *Syrrhopodon perarmatus*. **14** *Syrrhopodon platycerii*. **15** *Syrrhopodon prolifer*. **16** *Syrrhopodon semperi*. **17** *Syrrhopodon spiculosus*. **18** *Syrrhopodon stoneae*. **19** *Syrrhopodon trachyphyllus*. **20** *Syrrhopodon tristichus*.

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A new species of *Trichoglottis* (Orchidaceae) from eastern Kalimantan, Indonesia

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Abstract

Trichoglottis najibii Yudistira & Mustaqim is described here as a species new to science based on a specimen collected from eastern Kalimantan, Indonesian Borneo. The most unique characteristics of this species are the the labellum's lateral lobes adnate to the column and the 8–9 mm long cylindric and slightly curving spur. A detailed description, distribution, habitat and ecology, notes, illustrations, and photographs are provided for the new species.

Introduction

Trichoglottis Blume is a genus of orchids with around 85 species, characterized by climbing or pendulous stem, oblong or elliptic leaves, inflorescence usually with 1 to many flowers, rarely more, flowers with the immobile labellum, with some part adnate to the column or column foot, at the junction with the column with a raised tongue, stelidia often with hairs at the apex, and four pollinia (Seidenfaden et al. 1992; Pridgeon et al. 2014). Recently, three new species from this genus were described (Schuiteman 1998, Naive & Martyr 2018, Bandara et al. 2022).

A specimen of this genus not matching any known species was collected from the lowland forest in the eastern part of Borneo; an island with 34 *Trichoglottis* species known so far (POWO 2022). A thorough review of the literature and digital portal (Seidenfaden et al. 1992, Comber 1990, 2001, Schuiteman 1998, Wood 2000, Pelser et al. 2011-onwards, Kocyan & Schuiteman 2014, Naive & Martyr 2018, Bandara et al. 2022) as well as type specimens in various databases, i.e. JSTOR Global Plants (https://plants.jstor.org), showed that the recently collected specimen belongs to a species new to science and is described in this paper.

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Taxonomic Treatment

Trichoglottis najibii Yudistira & Mustaqim, *sp. nov.*

Type: INDONESIA, Kalimantan Timur, Berau Regency, Tabalar, Semurut, 70 m a.s.l., *M. Najib 001*, 25 July 2022 (holo: WAN).

Epiphytic herbs. *Roots* terete, 50–100 mm long, 1–2.5 mm wide, covered with silver velamen, burgundy near the apex. *Stem* pendent, 45–65 cm long, 4–5 mm diam., covered with leaf sheath, sheath slightly rugose; internodes 20–30 mm long. *Leaves* many, distichous, linear, 140–170 mm long, 5–8 mm wide, coriaceous, tapering into pointed apex, margin entire, glabrous. *Inflorescence* of 2–5-flowered arranged in clusters, from nodes. *Flowers* open widely, c. 30 mm across in diam, lasting about a week, resupinate, purple to crimson. *Pedicel* and *ovary* slightly angular, c. 20 mm long, c. 1 mm diam., white with magenta ribs, pink to white. *Median sepal* purple with darker veins, free, elliptic, upper part slightly hoody, c. 13 mm long, 3–5.5 mm wide, apex rounded, margins entire, glabrous. *Lateral sepals* entirely purple with darker veins, obliquely ovate, c. 14 mm long, 8 mm wide, apex acute, margins entire, glabrous. *Petals* free, entirely purple with darker veins, spatulate, c. 12 mm long, 6 mm wide, slightly smaller than sepals, margin entire, apex rounded, glabrous. *Labellum* trilobed, narrowly elliptic (not flattened), c. 4.5 mm long; *lateral lobes* with an oblique base, raised apically into a long, truncate lobes, margin entire, adnate to column to near apex, front margin c. 1.5 mm tall; *midlobe* narrowly lanceolate, c. 9 mm long, 1 mm wide, upper surface pubescent with short white hairs, apex acute, sub-acuminate, white to pink; *spur* pure white, slightly curving, cylindrical, narrowing towards the apex, 8–9 mm long, with two longitudinal purple band at the base, glabrous. *Column* oblong, 9–10 mm long, 2–3.5 mm wide, truncate; *stigma* obpentagonal, stelidia broadly triangular, glabrous; *column foot* short, 1.5 mm long. *Anther cap* obcordate, c. 2 mm long, 2 mm wide, brown. *Pollinia* waxy, subglobose to ovoid, entire, c. 1 m long, 1 mm wide, solid, red-burgundy, stipe rudimentary, viscidium distinct; *rostellum* bifid, c. 1.5 mm long, 1 mm wide, with a median tooth, the two main teeth sometimes strongly reflexed and fitting into two cavities on viscidium. *Capsule* green with burgundy dots, ellipsoid, triangular in cross section, 60–75 mm long, 4–10 mm wide, slightly warty, with 3 prominent longitudinal ridges. Figures 1, 2.

Diagnosis: This species is unique among *Trichoglottis* in having the upper side of labellum lateral lobes adnate to the column for almost their entire length and cylindrical, slightly curving spur 8–9 mm long.

Distribution: Endemic to East Kalimantan: known only from the type location.

Habitat and Ecology: Lowland mixed forest, hilly area north of Sangkulirang Mangkalihat range, at elevation c. 70 m a.s.l.

Phenology: Flowering from June to August.

Etymology: This new species is named after Muhammad Najib, an orchid enthusiast from East Kalimantan, Indonesia who collected the only known specimen.

Notes: The flower of *Trichoglottis najibii* is similar in color to *T. latisepala* Ames, a species endemic from the Philippines (Ames 1909; Pelser et al. 2011 onwards). However, in *T. najibii* flowers are larger (c. 22 mm vs 9–10 mm long) with the colouration of the upper half intense purple vs lighter purple, and the lower half pure white with longer spur (8–9 mm vs 3.5 mm long). In addition, the lower side of lateral sepals of *T. latisepala* form basal lobes.

In Borneo, the linear leaf lamina of this species is very similar to the Sarawak endemic *T. borneensis* (J.J.Wood) Kocyan & Schuit., and in the vegetative stage, it seems plants from both species cannot be differentiated. However, *T. borneensis* can be easily recognized by its pale lemon-yellow flowers, labellum creamy white hairs, and saccate spur with villous interior walls.

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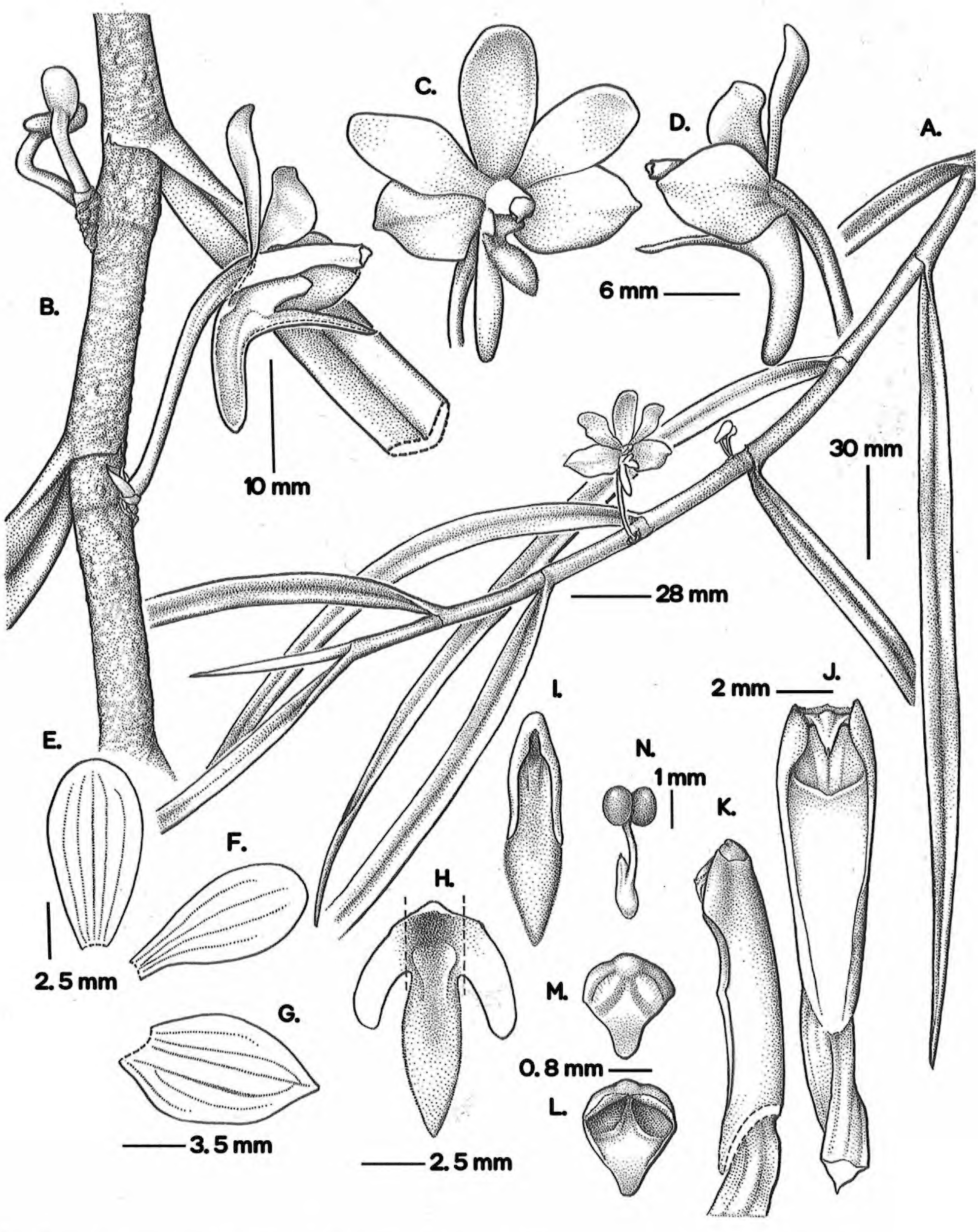

Fig. 1. *Trichoglottis najibii* Yudistira & Mustaqim. A: plant. B: inflorescences. C: flower, frontal view. D: flower, lateral view. E: dorsal sepal. F: lateral sepal. G: petal. H: labellum flattened shaped on top view. I: labellum natural shaped top view. J: column, ventral view. K: column, lateral view. L: anther cap abaxial side. M: anther cap, adaxial side. N: pollinia. Illustrated by Yuanito Eliazar (Voucher: *M. Najib 001*).

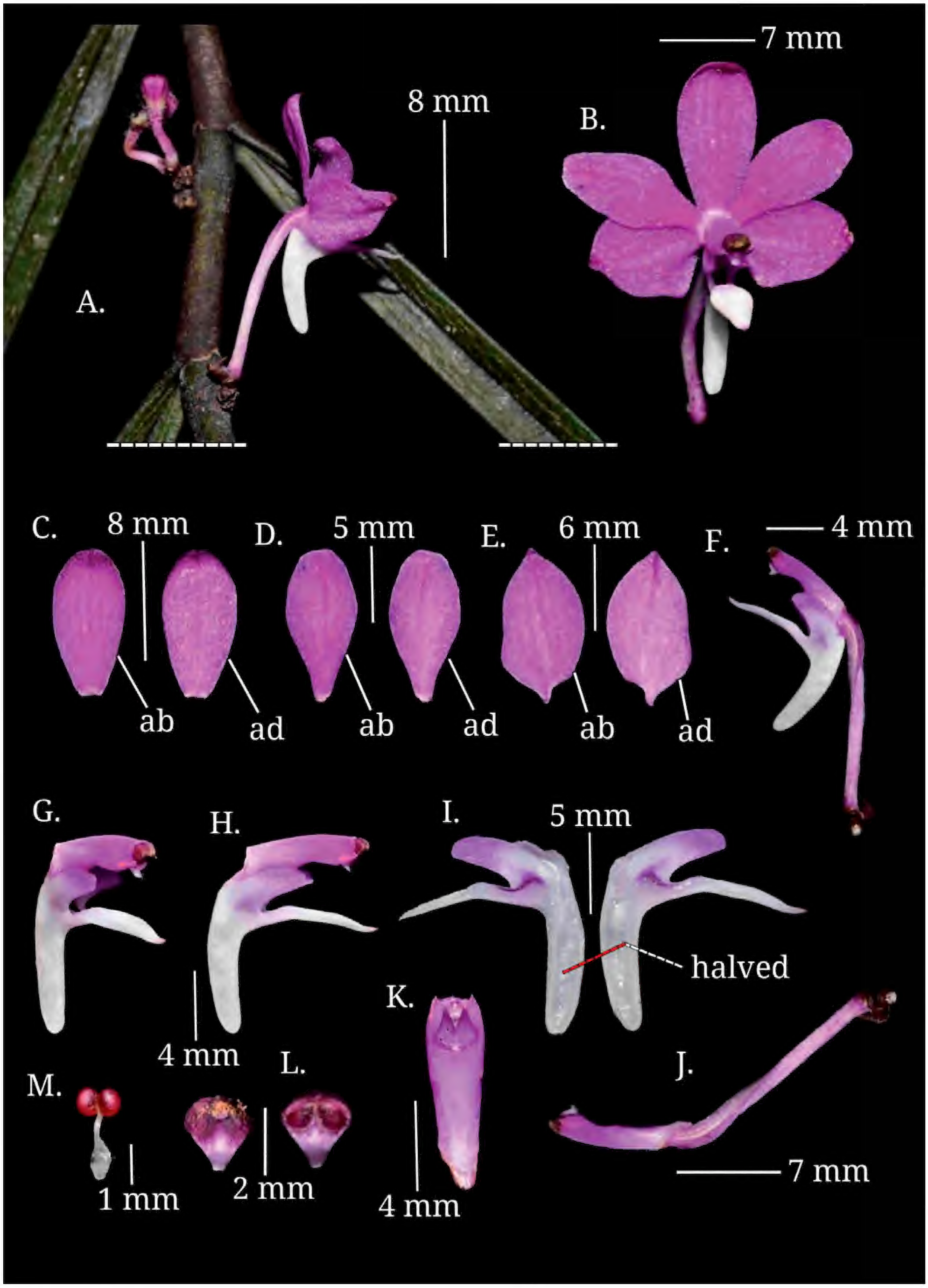

Fig. 2. *Trichoglottis najibii* Yudistira & Mustaqim. A: inflorescences. B: flower frontal view. C: median sepal abaxial and adaxial side. D: petals abaxial and adaxial side. E: lateral sepal abaxial and adaxial side. F: ovary, column, and labellum lateral view. G: column and labellum ventral view. H: column and labellum lateral view. I: labellum on halved. J: column and ovary. K: column abaxial side. L: anther cap adaxial and abaxial side. M: pollinia. Photographs by Yuda R. Yudistira (Voucher: *M. Najib 001*).

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Orthotrichaceae (Musci) of Palawan Island, with two species new to the Philippines

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Abstract

This paper provides an updated list of the Orthotrichaceae occurring in Palawan Island, the Philippines. Nine species are reported as new to the island. *Macromitrium clemensiae* E.B.Bartram and *M. megalocladon* M.Fleisch. are new country records, while the remaining seven species were previously reported in other islands of the Philippines. A key to the species of Orthotrichaceae in Palawan is provided. Descriptions and illustrations are provided for the two new country records. Notes and range extensions for each species reported are discussed.

Keywords: bryophytes, *Desmotheca*, *Groutiella*, *Macromitrium*, new records, range extensions, *Schlotheimia*.

Introduction

In the last published checklist of mosses of Palawan Island in the Philippines (Tan 1996), five species of Orthotrichaceae were recorded from the island: *Desmotheca apiculata* (Dozy & Molk.) Lindb. ex Cardot; *Macromitrium blumei* Nees ex Schwägr.; *Macromitrium cuspidatum* Hampe; *Macromitrium falcatulum* Müll.Hal.; and *Macromitrium salakanum* Müll.Hal. None of these species was exclusive to Palawan but also distributed on other islands in the Philippines (Tan and Iwatsuki 1991).

Previously undetermined collections of Orthotrichaceae from Palawan Island, mainly materials from previous expeditions of early field collectors from the Philippine National Herbarium (PNH), but also including collections from the authors now lodged in CAHUP, PPC, and VBGI, were studied as part of a broader floristic study of moss flora in Palawan Island. After being visited four times between 1987 and 1993 by B.C. Tan, the island was explored again in 2019–2022, which resulted in a significant number of collections. Several collections determined as either new country or island moss records from these recent expeditions have been published in an earlier paper (Linis and Logatoc 2023) with their collection details.

This paper reports nine additional orthotrichaceous species for the Palawan moss flora, with *Macromitrium clemensiae* E.B.Bartram and *M. megalocladon* M.Fleisch. representing the first report of these species for the country. *Groutiella tomentosa* (Hornsch.) Wijk & Margad., *Macromitrium angustifolium* Dozy & Molk., *M. fuscescens* Schwägr., *M. incurvifolium* (Hook. & Grev.) Schwägr., *M. longicaule* Müll.Hal., *M. zollingeri* Mitt. ex

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Bosch & Sande Lac., and *Schlotheimia wallisii* Müll.Hal. were all reported previously from other islands of the Philippines and are here reported for the first time in Palawan Island.

Taxonomic Treatment

Key to genera of Orthotrichaceae known from Palawan Island

1. Branches strongly dimorphic in length, leaf shape and leaf arrangement; short branches with longer, irregularly arranged leaves; elongated branches pentastichous, with shorter leaves; capsules almost sessile, immersed, wide-mouthed, gymnostomous ..... ***Desmotheca***

1. Branches not clearly dimorphic; capsules various, never almost sessile, generally narrowed toward mouth, rarely gymnostomous 2

2. Leaf apices generally obtuse to truncate or retuse, often hair-pointed; basal leaf cells prorate; dioicous; calyptrae large, smooth, laciniate at the base (with 4–8 inflexed flaps); peristomes double, well developed ..... ***Schlotheimia***

2. Leaf apices variously shaped, generally acute to acuminate, if obtuse, never hair-pointed; basal leaf cells smooth or tuberculate, never prorate; dioicous or phyllodioicous; calyptrae plicate, hairy or not, small, never laciniate at base; peristomes lacking, single or, if double, rudimentary 3

3. Leaf apices subulate, fragile and brittle (all, except those of the youngest leaves usually broken off); upper leaf cells pluristratose; dioicous and isosporous; calyptrae covering only upper halves of the capsules ..... ***Groutiella***

3. Leaf apices rarely brittle; upper leaf cells unistratose; phyllodioicous and anisosporous; male plants dwarf; calyptrae fully covering capsules or nearly so ..... ***Macromitrium***

Desmotheca Lindb.

Desmotheca apiculata (Dozy & Molk.) Lindb. ex Cardot, *Ann. Jard. Bot. Buitenzorg, Suppl.* 1: 11. 1897. *Cryptocarpon apiculatum* Dozy & Molk., *Ann. Sci. Nat., Bot.*, sér. 3, 2: 302. 1844. *Type*: Indonesia, Kalimantan (Borneo), *P.W. Korthals s.n.* (holotype: L, not seen).

Descriptions: Fleischer (1904: 463–466), Bartram (1939: 186), Vitt *et al.* (1995: 87–91), Eddy (1996: 94).

Illustrations: Fleischer (1904: 464, fig. 86), Vitt *et al.* (1995: 89, fig. 38a–n), Eddy (1996: 95, fig. 394).

Notes: *Desmotheca apiculata* is readily distinguished from other species of Orthotrichaceae occurring in Palawan Island by its noticeably dimorphic branches, the fertile elongated branches having small, ranked, imbricate leaves terminated by several perichaetia with totally immersed, smooth capsules lacking peristomes. Other key features include creeping stems, dimorphic, apiculate leaves with tuberculate basal leaf cells and excurrent costa, short and hairy calyptrae, and immersed capsules (Vitt *et al.* 1995; Eddy 1996). *Desmotheca apiculata* is distributed in Southeast Asia, including the Andaman Islands, Papua New Guinea, and New Caledonia (Vitt 1990). In the Philippines, this species is recorded from the islands of Palawan (Tan 1996) and Mindanao (Tan and Iwatsuki 1991). *Desmotheca apiculata* is usually epiphytic, often growing on branch and tree trunks of open and disturbed forests, also in gardens and plantations across its range below 1600 m elev.

Specimen examined: Palawan Island: Narra Municipality, Mt Victoria, ridge, montane rainforest along the trail leading to the summit, ca 1602 m elev., N 09° 22' 17.56" E 118° 18' 20.38", on the branch of a tree, 23 December 2022, *Linis 5905-22a* (CAHUP, PPC, VBGI).

Groutiella Steere

Groutiella tomentosa (Hornsch.) Wijk & Margad., *Taxon* 9(2): 51. 1960. *Macromitrium tomentosum* Hornsch., *Fl. Bras.* 1(2): 21. 1840. *Type*: Brazil, in campis montevidensibus, *Sellow s.n.* (lectotype: H-BR 2726013, designated by Yu *et al.* 2011).

Groutiella goniorrhyncha (Dozy & Molk.) E.B.Bartram, *Rev. Bryol. Lichénol.* 23: 250. 1954. *Micromitrium goniorrhynchum* (Dozy & Molk.) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1872–73: 157. 1874. *Macromitrium goniorrhynchum* (Dozy & Molk.) Mitt., *J. Proc. Linn. Soc., Bot., Suppl.* 1: 53. 1859. *Schlotheimia goniorrhyncha* Dozy & Molk., *Pl. Jungh.* 3: 338. 1854. *Type*: Indonesia, Java, Semarang (Samarang) Province, Mt Ungaran, *Junghuhn s.n.* (lectotype: L0623557, designated by Touw 2007).

Descriptions: Fleischer (1904: 456–459, as *Micromitrium goniorhynchum*), Bartram (1939: 183–184, as *Macromitrium goniorhynchum*), Vitt and Ramsay (1985: 431–434), Vitt *et al.* (1995: 85–86), Eddy (1996: 82–84).

Illustrations: Fleischer (1904: 457, fig. 84, as *Micromitrium goniorhynchum*), Vitt and Ramsay (1985: 432–433, figs. 333–340), Vitt *et al.* (1995: 87, fig. 37a–g), Eddy (1996: 83, fig. 386; 84, fig. 387).

Notes: Bartram (1939) first reported this species in the Philippines as *Macromitrium goniorhynchum* [sic], which he later treated as *Groutiella goniorhyncha* [sic] (Bartram, 1954). Yu *et al.* (2011) eventually placed the species in synonymy with the pantropical *Groutiella tomentosa*. This species is distinguished by its prostrate stems with short, erect branches and fragile, subulate leaves bordered in their lower portions by several rows of elongate, thick-walled cells that contrast sharply with the inner oblate to rounded basal cells.

In the Philippines, *Groutiella tomentosa* has a relatively broad distribution and is recorded from the islands of Luzon, Catanduanes, Mindoro, Panay, and Mindanao (Tan and Iwatsuki 1991; Linis 2009, 2014; Tan *et al.* 2015). Only one specimen, collected by the first author from Mt Victoria, has been identified from the central part of Palawan. This plant was collected from the upper tree trunk and branches of a tree in the montane forest over the mountain ridge. Across the country, *G. tomentosa* is a common plant usually found as an epiphyte, on tree trunks, branches, and twigs, rarely on rock, and has been observed from lowlands up to *ca* 1500 m elev. The species can be common in gardens and similar sites prone to desiccations for a considerable period.

Specimen examined: Palawan Island: Narra Municipality, Mt Victoria, ridge, montane rainforest along the trail leading to the summit, *ca* 1620 m, N 09° 22' 17.56"; E 118° 18' 20.38", on upper tree trunk and branches, 23 December 2022, *Linis 5919-22* (CAHUP, PPC, VBGI).

Macromitrium Brid.

Key to species of *Macromitrium* known from Palawan Island

1. Basal leaf cells elongate-rectangular, smooth, without tuberculae, not bulging 2
1: Basal leaf cells rounded oval to elongate rectangular, bulging, conic or at least some cells with tuberculae 7
2. Basal leaf cells with straight to shallow-sigmoid or somewhat curved lumen ..... *M. incurvifolium*
2: Basal leaf cells with distinctly curved or sigmoid lumen 3
3. Leaves long-cuspidate, > 3.5 mm long; costae long-excurrent ..... *M. cuspidatum*
3: Leaves obtuse, mucronate, acuminate-apiculate to long and slenderly acute, < 3.0 mm long; costae percurrent to short excurrent 4
4. Plants glaucous-green; transitions from basal leaf cells to upper leaf cells sharp (with 1–3 cell tiers); costae excurrent ..... *M. fuscescens*
4: Plants olive-green to reddish; transitions from leaf basal cells to upper leaf cells gradual (within 5–10 cell tiers); costae excurrent to percurrent 5
5. Perichaetium almost vestigial, with 1–4 bracts smaller than vegetative leaves, not concealing vaginula ..... *M. falcatulum*
5: Perichaetium not reduced, composed of perichaetial leaves concealing the vaginula 6
6. Perichaetial leaves obtuse, retuse, mucronate; costae excurrent ..... *M. salakanum*
6: Perichaetial leaves acute to acuminate; costae percurrent or excurrent ..... *M. angustifolium*
7. Seta smooth ..... *M. longicaule*
7: Seta papillose or scabrid 8
8. Plants small; branches less than 1.0 cm long; leaves less than 2.0 mm long 9
8: Plants moderately robust to robust; branches more than 1.0 cm long; leaves more than 2.0 mm long 10
9. Perichaetial leaves broadly pointed; costa short to moderately excurrent ..... *M. blumei*
9: Perichaetial leaves acuminate; costa strongly excurrent ..... *M. zollingeri*

10. Inner basal leaf cells short, strongly differentiated from *ca* 10 rows of elongated, smooth, outer marginal basal leaf cells ..... *M. clemensiae*

10: Inner basal leaf cells, elongate, more or less similar to elongate, outer marginal basal leaf cells..... *M. megalocladon*

Macromitrium angustifolium Dozy & Molk., *Musc. Frond. Archip. Ind.* 16. 1844. *Type*: Indonesia, Sumatra, Java, and Kalimantan (Borneo), *P.W. Korthals s.n.* (lectotype: L0060422, annotated by Vitt and published by Touw 2007).

Descriptions: Noguchi (1989: 616), Bartram (1939: 178–179), Vitt *et al.* (1995: 17–19), Eddy (1996: 46).

Illustrations: Noguchi (1989: 615, fig. 273, B), Vitt *et al.* (1995: 18, fig. 7a–k), Eddy (1996: 47, fig. 358).

Notes: *Macromitrium angustifolium* is the most common species of the genus on the island of Luzon in the Philippines. The lustrous yellowish green to olive-green colour, squarrose leaves when moist, percurrent costa, sharply and narrowly acute leaf apices, papillose upper leaf cells, elongate, curved-sigmoid, non-tuberculose basal cells, strongly differentiated outer and inner perichaetial leaves, narrowly elliptic smooth capsules, and sparsely hairy calyptrae are diagnostic for this species (Vitt *et al.* 1995). In some Philippine materials, the leaves are gradually narrowed to slenderly, acute leaf apices, and the costa ends 1–2 cells below the apex, similar to those in New Guinea (Vitt *et al.* 1995). In contrast, specimens with shortly acuminate leaf apices with excurrent costae can be confused with those of other Philippine *Macromitrium* species, such as *M. fuscescens* and *M. salakanum*. A thorough molecular investigation may reveal some cryptic diversity within this species, although until further data are available, we can continue with the broad species concept currently adopted.

Macromitrium angustifolium is a widespread tropical Asian species that occurs in Mainland China, Sumatra, Java, Borneo, Sulawesi, the Philippines, New Guinea, and the Solomon Islands (Vitt *et al.* 1995; Guo *et al.* 2012). It is reported here as new to Palawan Island, extending its current Philippine range to the south from Luzon, Mindoro and Camiguin (Bartram 1939; Tan and Iwatsuki 1991; Linis 2009, 2014). This species was collected in the tropical lower montane rainforest of Mt Salakot and the tropical subalpine forest in the summit area of Mt Mantalingahan. Across the country, *M. angustifolium* is mainly a sub-canopy epiphyte occurring on tree branches, trunks, and logs in disturbed or secondary forests.

Specimens examined: Palawan Island: Puerto Princesa City, Mt Salakot, mossy rainforest along the trail above the small helicopter landing site, *ca* 1100 m, on a tree trunk, 05 May 1979, *Wm. Sm. Gruèzo WM6449* (personal herbarium of W.S. Gruèzo; VBGI); Rizal Municipality, Mt Mantalingahan, tropical subalpine forest near the summit, 2068 m elev., on the trunk of a hardwood tree, 09 January 2020, *E.L.R. Logatoc 20-0127* (CAHUP, VBGI), tropical subalpine forest, *ca* 1900 m elev., on top of a boulder, 09 January 2020, *E.L.R. Logatoc 20-0132* (CAHUP, PPC, VBGI).

Macromitrium blumei Nees ex Schwägr., *Sp. Musc. Frond., Suppl.* 4: 316. 1842. *Type*: Indonesia, Java, *Blume s.n.* (holotype: BM, not seen; isotype: H-BR, not seen).

Macromitrium copelandii Broth., *Philipp. J. Sci., C.* 3: 16. 1908. *Type*: Philippines, Bataan Province, Mt Mariveles, *E.B. Copeland s.n.* (isotype: NY, not seen).

Descriptions: Fleischer (1904: 424–428), Bartram (1939: 175–176), Eddy (1996: 74–76), Guo *et al.* (2012: 348–450).

Illustrations: Fleischer (1904: 425), Eddy (1996: 75, fig. 382), Guo *et al.* (2006: 477; 2012: 349, figs. 56–65).

Notes: *Macromitrium blumei* are small mat-forming plants that can be distinguished from other Philippine species of the genus by: small branch leaves, densely coiled around the stem, forming "rope-like" shoots; isodiametric, bulging to mammillate upper leaf cells; elongate, pellucid, incrassate lower leaf cells with distinct papillae or tubercles; seta up to 16 mm long; urceolate smooth capsule with the short cylindrical mouth; double peristomes; and naked calyptrae (Guo *et al.* 2012). This species is closely related to *M. zollingeri* Mitt. ex Bosch & Sande Lac. (Guo *et al.* 2006), another species in the genus reported here as new for Palawan. The taxonomic status here adopted and the distinction between these two mosses is discussed under the latter.

Macromitrium blumei is a tropical Asian species reported from Hainan, Sumatra, Java, Borneo, Lombok, and the Philippines (Eddy 1996). In the Philippines, *M. blumei* was reported in Luzon, Mindoro, Palawan, Negros, and Mindanao (Tan and Iwatsuki 1991; Tan 1996; Linis 2009). In Palawan, this species was collected on tree trunks and fallen branches in the tropical lower and tropical upper montane rainforests. Across its range in the Philippines, *M. blumei* is usually found as an epiphyte on tree trunks and twigs and has been observed from lowlands up to ca 1600 m.

Specimens examined: Palawan Island: Rizal Municipality, Mt Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, *ca* 1600 m elev., on the trunk of a hardwood tree, 27 July 2019, *E.L.R. Logatoc 19-0337* (CAHUP, PPC, VBGI), on the trunk of a hardwood tree, 09 January 2020, *E.L.R. Logatoc 20-0152*, *20-0153* (CAHUP, VBGI); Brooke's Point Municipality, Mt Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, *ca* 1300 m elev., on a fallen branch, *E.L.R. Logatoc 20-0100*, *20-0101* (CAHUP, VBGI).

Macromitrium clemensiae E.B.Bartram, *Philipp. J. Sci.* 61: 242. 1936. *Type*: Malaysia, Borneo, Mt Kinabalu, Penibukan, *J. Clemens & M.S. Clemens 40531* (holotype: FH00213595, not seen).

Description: Plants fairly robust; young shoots yellowish green, gradually turning to reddish brown at mature portions. Stems creeping, covered with tomentum, stem leaves inconspicuous; branches erect, up to 2.0 cm tall. Branch leaves narrowly lanceolate, loosely erect and crisped when dry, arcuate patent to almost squarrose when moist, 2.5–3.0 mm long and 0.4–0.5 mm wide across the weakly developed shoulders, carinate; margins plane; apices narrowly acuminate, irregularly dentate; costa percurrent to short-excurrent. Upper leaf cells quadrate to short-rectangular, up to 10 μm wide, evenly incrassate, internal walls slightly thickened, densely pluripapillose and obscure. Basal leaf cells dimorphic; interior cells uniformly elongate, up to 20 μm long, evenly incrassate, mostly conspicuously tuberculate; marginal cells narrow and smooth, forming a strongly differentiated pellucid band of cells along lower margins, up to 1/3 length of the leaves. Perichaetial leaves narrowly lanceolate, conspicuously erect, longer than branch leaves, up to 3.5 mm long. Seta 8.0–9.0 mm long, papillose, twisted. Capsule ovoid, up to 2.0 mm long and 1.0 mm wide; peristome teeth fused, forming a continuous membrane, up to 50 μm long. Calyptra mitrate, plicate, hairy, up to 4.0 mm long.

Illustration: Fig. 1; Eddy (1996: 45, fig. 357).

Notes: Several Philippine species of *Macromitrium* have tuberculate basal cells; however, the markedly differentiated broad bands of pellucid cells along the lower leaf margins easily distinguish *M. clemensiae* from others. Outside the Philippines, *M. clemensiae* is similar to the New Guinea endemic *M. norrisianum* Vitt having similar bordered lower leaf margins. However, the larger *M. norrisianum* has rounded to rounded-quadrate bulging upper leaf cells with firm walls (Vitt *et al.* 1995). In contrast, similar cells of *M. clemensiae* are quadrate, densely pluripapillose, and obscure, with less thickened cell walls. *Macromitrium clemensiae* without sporophytes can be mistaken for a species of *Groutiella*. The persistent, unistratose, and dentate leaf apices of *M. clemensiae* affords an alternative to distinguish it from this genus (Eddy 1996).

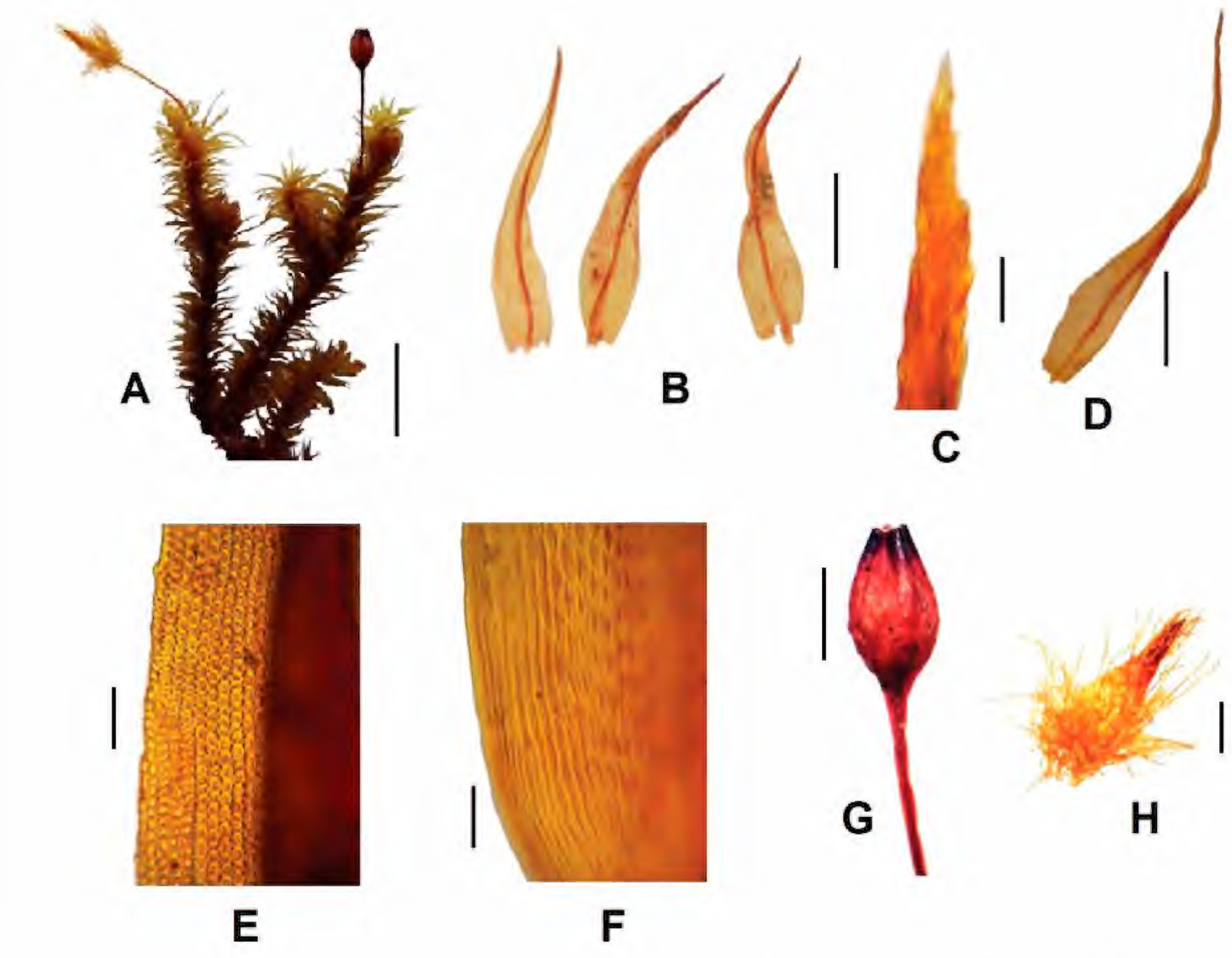

Fig. 1. *Macromitrium clemensiae* Bartram. **A**: Habit of plant, moist. **B**: Leaves, adaxial view. **C:** Leaf apex, adaxial view. **D:** Perichaetial leaf, adaxial view. **E.** Median leaf cells. **F.** Basal leaf cells near margin. **G:** Capsule. **H.** Calyptra. All from *E.L.R. Logatoc 20-0145* (CAHUP). Scale bars: A = 5 mm; B, D, G = 1 mm; C = 20 μm; E, F = 40 μm; H = 2 mm.

Macromitrium clemensiae is only known from Borneo (Bartram 1936; Higuchi *et al.* 2006) until now. Reported here for the first time in the Philippines, it appears to be a rare plant, being the specimen *E.L.R. Logatoc 20-0145* the fifth published record of this species. *Macromitrium clemensiae* is usually found as an epiphyte on branches and twigs of trees, fallen branches and tree trunks.

Specimen examined: Palawan Island: Rizal Municipality, Mt Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, *ca* 1700 m elev., on a fallen branch, 09 January 2020, *E.L.R. Logatoc 20-0145* (CAHUP, PPC, VBGI).

Macromitrium cuspidatum Hampe, *Icon. Musc.* (*Hampe*): pl. 20. 1844. *Type*: Indonesia, Java, *Junghuhn s.n.* (lectotype: BM, designated by Vitt *et al.* 1995).

Descriptions: Bartram (1939: 180), Vitt *et al.* (1995: 27–29), Eddy (1996: 49–50), Guo *et al.* (2012: 342).

Illustrations: Vitt *et al.* (1995: 28, fig. 12a–j), Eddy (1996: 50, fig. 361), Guo *et al.* (2012: 343).

Notes: *Macromitrium cuspidatum* are robust yellowish-green plants forming mats or cushions. The broad, loosely erect leaves and the ovoid capsules on short setae can distinguish this species from its congeners in the field. Under the microscope, the species is readily identified by the long cuspidate leaves with a long-excurrent solid costa and the smooth, asymmetrically thickened cells with curved-sigmoid narrow lumina restricted to the basal leaf area (Vitt *et al.* 1995; Eddy 1996).

Macromitrium cuspidatum is another example of a widespread tropical Asian *Macromitrium* species, having been reported from China and the northern and western parts of Malesia, reaching Papua New Guinea (Vitt *et al.* 1995; Eddy 1996; Guo *et al.* 2012). Locally, it is reported from Luzon, Mindoro, Palawan, Panay, and Mindanao (Tan and Iwatsuki 1991; Tan 1996; Linis 2009; Tan and Shevock 2015). In the Philippines, *M. cuspidatum* was collected on tree trunks and branches in semi-open areas of tropical lowland forests up to *ca* 1600 m.

Specimen examined: Palawan Island: Narra Municipality, Mt Victoria, ridge, montane rainforest along the trail leading to the summit, *ca* 1602 m elev., N 09° 22' 17.56" E 118° 18' 20.38", on a branch of an understory tree, 23 December 2022, *Linis 5893-22* (CAHUP, PPC, VBGI).

Macromitrium falcatulum Müll.Hal., *Linnaea* 38: 558. 1874. *Type*: Philippines, *H. Cuming 2212* (lectotype: NY, designated by Vitt *et al.* 1995; isotype: BM, not seen).

Macromitrium merrillii Broth., *Öfvers. Finska Vetensk.-Soc. Förh.* 47(14): 4. 1905. *Type*: Philippines, Luzon, Tarlac Province, *Merrill 3590* (holotype: H-BR, not seen).

Macromitrium winkleri Broth., *Bot. Jahrb. Syst.* 49: 350. 1912. *Type*: Indonesia, Kalimantan (Borneo), Hayup, *Winkler n. 2117* (lectotype: H-BR, designated by Vitt *et al.* 1995).

Descriptions: Bartram (1939: 174–175), Vitt *et al.* (1995: 32–33), Eddy (1996: 38–40).

Illustrations: Vitt *et al.* (1995: 33, fig. 14a–j), Eddy (1996: 40, fig. 352).

Notes: *Macromitrium falcatulum* are short, small plants distinguished by the tightly inrolled leaves, densely papillose upper leaf cells, rounded-tuberculate basal leaf cells, tiny perichaetial leaves with exposed vaginula, and densely hairy calyptrae (Vitt *et al.* 1995). When dry, plants of this species can be mistaken as *M. tylostomum* Mitt. ex Bosch & Sande Lac. However, the latter is a larger species with smooth, bulging upper leaf cells and long-acuminate perichaetial leaves. This species is also similar in appearance to *M. nepalense* (Hook. & Grev.) Schwägr.; however, the latter has tuberculate basal cells in the lower half of the leaves, and the capsules are fusiform, not short ovoid, as in *M. falcatulum* (Eddy 1996).

Macromitrium falcatulum has been reported from Indochina, Peninsular Malaysia, Borneo, the Philippines, and New Guinea (Tan and Iwatsuki 1993; Vitt *et al.* 1995). It is reported from the Philippine islands of Batan, Luzon, Palawan, and Mindanao (Tan and Iwatsuki 1991; Tan 1996). This species is mainly corticolous in open and relatively dry situations, particularly in disturbed secondary lowland forests.

Specimen examined: Palawan Island: Narra Municipality, Barangay Princess Urduja, secondary lowland rainforest beside the trail along Buhawi River from Base Camp leading to the summit, *ca* 1200 m elev., N 09° 21' 13.14" E 118° 18' 25.20", on the trunk of a tree, associated with *Calymperes porrectum*, 22 December 2022, *Linis 5867-22b* (CAHUP, PPC, VBGI).

Macromitrium fuscescens Schwägr., *Sp. Musc. Frond., Suppl.* 2, 2(2): 129. 1827. *Type*: Marianas, in insulis Marianis, *Gaudichaud s.n.* (lectotype: G, designated by Vitt *et al.* 1995; isotype: G, not seen).

Macromitrium semipellucidum Dozy & Molk., *Musc. Frond. Archip. Ind*. 17. 1844. *Type*: Indonesia, Kalimantan (Borneo) and Java (lectotype: L, designated by Vitt *et al.* 1995).

Descriptions: Bartram (1939: 178, as *M. semipellucidum*), Vitt *et al.* (1995: 33–36), Eddy (1996: 52, as *M. semipellucidum*).

Illustrations: Vitt *et al.* (1995: 34, fig. 15a–i), Eddy (1996: 52–53, fig. 365, as *M. semipellucidum*).

Notes: *Macromitrium fuscescens* are small to medium-sized, whitish green plants characterised by the squarrose-spreading leaves when moist, often inflexed leaf apices, excurrent costae, very small and obscure upper leaf cells, elongate and transparent basal leaf cells with sigmoid lumens, 16 irregular peristome teeth, and hairy calyptrae (Vitt *et al.* 1995). This species can be distinguished from other members of the "*M. gracile*" group (Vitt and Ramsay 1985) found in Palawan by the broader, acuminate, and longer mucronate apices versus the gradually narrowed, slenderly acute apices of *M. angustifolium* and the somewhat broader, acuminate, and longer mucronate apices of *M. salakanum* (Vitt *et al.* 1995).

This low-elevation species is somewhat widespread in Southeast Asia up to the Pacific Islands (Vitt *et al.* 1995). In the Philippines, *M. fuscescens* was reported in Luzon, Panay, and Mindanao (Tan and Iwatsuki 1991 as *M. semipellucidum*), mainly at lower elevations up to 1000 m. In Palawan, the species was collected on a fallen branch in the tropical lower montane rainforest of Mt Mantalingahan, representing a new record for the island.

Specimen examined: Palawan Island: Brooke's Point Municipality, Mt Mantalingahan, tropical lower montane rainforest, *ca* 900 m elev., on a fallen branch, 05 January 2020, *E.L.R. Logatoc 20-0042* (CAHUP, PPC, VBGI).

Macromitrium incurvifolium (Hook. & Grev.) Schwägr., *Sp. Musc. Frond., Suppl.* 2, 2(2): 144. 1827. *Orthotrichum incurvifolium* Hook. & Grev., *Edinburgh J. Sci*. 1: 117. 1824. *Type*: Indonesia, Ternate Island and in King Georges Sound, *s.coll.* (lectotype: E-Greville, designated by Vitt and Ramsay 1985).

Macromitrium subtile Schwägr., Sp. Musc. Frond., Suppl. 2, 2(2): 140. 1827. *Type*: Society Islands, Tahiti, in insula Otaheite, *A. Menzies s.n.* (lectotype: G-Schwägrichen, designated by Vitt and Ramsay 1985).

Macromitrium subuligerum Bosch & Sande Lac., Bryol. Jav. 1: 124. 1860. *Type*: Indonesia, Java, Mts Gede and Salak, *Teysmann s.n.* (lectotype: L, designated by Vitt *et al.* 1995).

Macromitrium planocespitosum Müll. Hal., Linnaea 38: 560. 1874. *Type*: Philippines, Luzon, Majayjay (Mahahai), *Wallis 1871* (lectotype: H-BR, designated by Vitt *et al.* 1995).

Macromitrium foxworthyi Broth., Philipp. J. Sci., C. 3: 16. 1908. *Type*: Philippines, Luzon, Pampanga Province, Mt Abu, *Foxworthy 1932* (holotype: H-BR, not seen).

Descriptions: Bartram (1939: 177 as *M. foxworthyi*; 177–178 as *M. subuligerum*), Vitt and Ramsay (1985: 415–419), Vitt *et al.* (1995: 36–39), Eddy (1996: 46–47; 49 as *M. subtile*).

Illustrations: Vitt and Ramsay (1985: 416–417, figs. 275–284), Vitt *et al.* (1995: 37, fig. 16a–j), Eddy (1996: 48, fig. 359; 50–51, fig. 363 as *M. subtile*).

Notes: *Macromitrium incurvifolium* are medium-sized plants, with olive-green shoots eventually turning rusty-brown in older parts. In Palawan Island, *M. incurvifolium* can appear somewhat like a miniature version of *M. angustifolium* and, at times, can be confused with *M. fuscescens* and *M. salakanum*. *Macromitrium incurvifolium* is distinguished from those as mentioned above by the: erect-incurved leaves when moist; acuminate-mucronate leaf apices; short excurrent costa; densely papillose upper leaf cells; short and wide-lumened transitional cells; short-rectangular, curved to straight, non-tuberculate basal cells; very short, non-sheathing, ovate-acuminate perichaetial leaves; and the hairy calyptrae (Vitt *et al.* 1995). Vitt and Ramsay (1985) provided a detailed discussion on the difference of this species from related species found in Australasia.

Commonly found at low elevations in relatively open and disturbed habitats, *Macromitrium incurvifolium* occurs in East Asia, Malesia, northern Australia, and Oceania (Vitt *et al.* 1995; Eddy 1996). In the Philippines, the species was reported in several localities from Luzon and once each from Mindoro, Panay, and Mindanao [Tan and Iwatsuki 1991 as *M. subtile* var. *subuligerum* (Bosch & Sande Lac.) M.Fleisch.]. Our single collection of *M. incurvifolium* from Palawan represents a new record of this species for the island.

Specimen examined: Palawan Island: Narra Municipality, Mt Victoria, ridge, montane rainforest along the trail leading to the summit, *ca* 1602 m elev., N 09° 22' 17.56"; E 118° 18' 20.38", on a tree branch, mixed with *Macromitrium blumei*, 23 December 2022, *Linis 5906-22b* (CAHUP, PPC, VBGI).

Macromitrium longicaule Müll.Hal., *Syn. Musc. Frond.* 1: 742. 1849. *Type*: Indonesia, Java, *Miquel s.n.* (lectotype: L, designated by Vitt *et al.* 1995).

Descriptions: Fleischer (1904: 451–453), Vitt *et al.* (1995: 39–42), Eddy (1996: 64–66).

Illustrations: Fleischer (1904: 452, fig. 83), Vitt *et al.* (1995: 40, fig. 17a–k), Eddy (1996: 64–65, fig. 374).

Notes: *Macromitrium longicaule* are moderately sized, olive-green plants forming loose to dense spreading mats. This species is distinguished from its congeners by the: sheathing leaf bases; short, densely papillose upper leaf cells; relatively longer tuberculate basal leaf cells; short setae, which are often double in a perichaetium; and the non-sheathing perichaetial leaves with long-flexuose acumen, giving a bristle-like appearance when dry (Vitt *et al.* 1995).

Macromitrium longicaule is widespread in Malesia, and has been reported to occur in the Philippines, Borneo, Java, and New Guinea (Tan and Iwatsuki 1991; Eddy 1996). According to Vitt *et al.* (1995), this species has a broad ecological and elevation range in Papua New Guinea, occurring as an epiphyte in primary and secondary lowland rainforests, montane rainforests, scrub vegetation, and gardens from 600–2850 m elev. In the Philippines, this species was reported from Luzon and Mindanao (Tan and Iwatsuki 1991), mainly on tree trunks and branches in the upper canopies of montane rainforests. In Palawan, this species was collected on the base of a tree growing in ultramafic outcrops at *ca* 1600 m elev. representing a new record for the island.

Specimen examined: Palawan Island: Rizal Municipality, Mt Mantalingahan, montane heath-over-ultramafic rocks, *ca* 1600 m elev., on the base of a hardwood tree, 26 July 2019, *E.L.R. Logatoc 19-0294* (CAHUP, PPC, VBGI).

Macromitrium megalocladon M.Fleisch., *Hedwigia* 50: 282. 1911. *Type*: Indonesia, West Irian, Jayawijaya, *Römer 718* (lectotype: FH, designated by Vitt *et al.* 1995).

Description: Plants large and stiff, rigidly branched; young shoots golden, yellowish green to olive-green, gradually turning reddish brown at mature portions; in loose mats. Stems creeping, poorly differentiated; branches erect, up to 5.0 cm long. Stem and branch leaves ovate-lanceolate to lanceolate, contorted and wide-spreading from an erect base when dry, stiffly wide-spreading to squarrose-recurved and in 5 distinct ranks when moist, 2.0–3.5 mm long and 0.4–0.5 mm wide; margins plane to reflexed; apices narrowly acute, strongly keeled above, with projecting papillae; costa percurrent. Upper leaf cells rounded to rounded short-elliptic, up to 14 μm wide, evenly incrassate, strongly convex, unipapillose to highly tuberculate, papilla tall and acute, clear, marginal cells somewhat smaller. Median leaf cells rounded-rhombic to short-elliptic, 10–20 μm long and 9–12 μm wide, convex, unipapillose. Basal leaf cells near insertion elongate-rectangular, 20–60 μm long and 7–10 μm wide, irregularly incrassate, straight, flat, smooth, clear; cells above elliptic-rectangular, 20–30 μm long and 9–11 μm wide, irregularly incrassate, nearly flat, unipapillose. Sporophyte not seen.

Illustrations: Fig. 2; Vitt *et al.* (1995: 46, fig. 19a–i; 47, fig. 20a–c), Eddy (1996: 39, fig. 351).

Notes: In the field, plants of *Macromitrium megalocladon* may be confused with species of *Trachypodopsis* M.Fleisch. due to the robust and stiff habit (Eddy 1996). On the other hand, this species can be distinguished from other Philippine *Macromitrium* species with tuberculate upper and lower leaf cells by the: robust and stiff habit; squarrose leaves in distinct ranks when moist; strongly convex upper leaf cells with tall and acute papilla; large tuberculae; prorate seta; and densely hairy calyptrae (Vitt *et al.* 1995). According to Eddy (1996), *Macromitrium megalocladon* is most similar to *M. ochraceum* (Dozy & Molk.) Müll.Hal. However, the unipapillose to tuberculate upper leaf cells and the elimbate leaf margin distinguishes *M. megalocladon* from the latter.

Macromitrium megalocladon was previously known in New Guinea and Sulawesi (Vitt *et al.* 1995; Eddy 1996). It is recorded here in the Philippines for the first time, from Palawan Island. In New Guinea and Sulawesi, specimens have been observed from *ca* 1800 m to over 3000 m elev., and although *M. megalocladon* plants are known as epiphytic and photophilic, many have been collected from rotting wood, tree bases, shrubs, and stumps; these plants are also known to occur on rocks and soil occasionally (Vitt *et al.* 1995). According to Vitt *et al.* (1995), the type specimen was labelled as occurring "terrestrial". Coincidentally, the Philippine materials were collected on a "litter-covered boulder".

Specimens examined: Palawan Island: Rizal Municipality, Mt Mantalingahan, montane heath-over-ultramafic rocks, *ca* 1600 m elev., on a litter-covered boulder, 26 July 2019, *E.L.R. Logatoc 19-0292* (CAHUP, PPC, VBGI), tropical subalpine forest, *ca* 1900 m elev., on a litter-covered boulder, 09 January 2020, *E.L.R. Logatoc 20-0133* (CAHUP, VBGI).

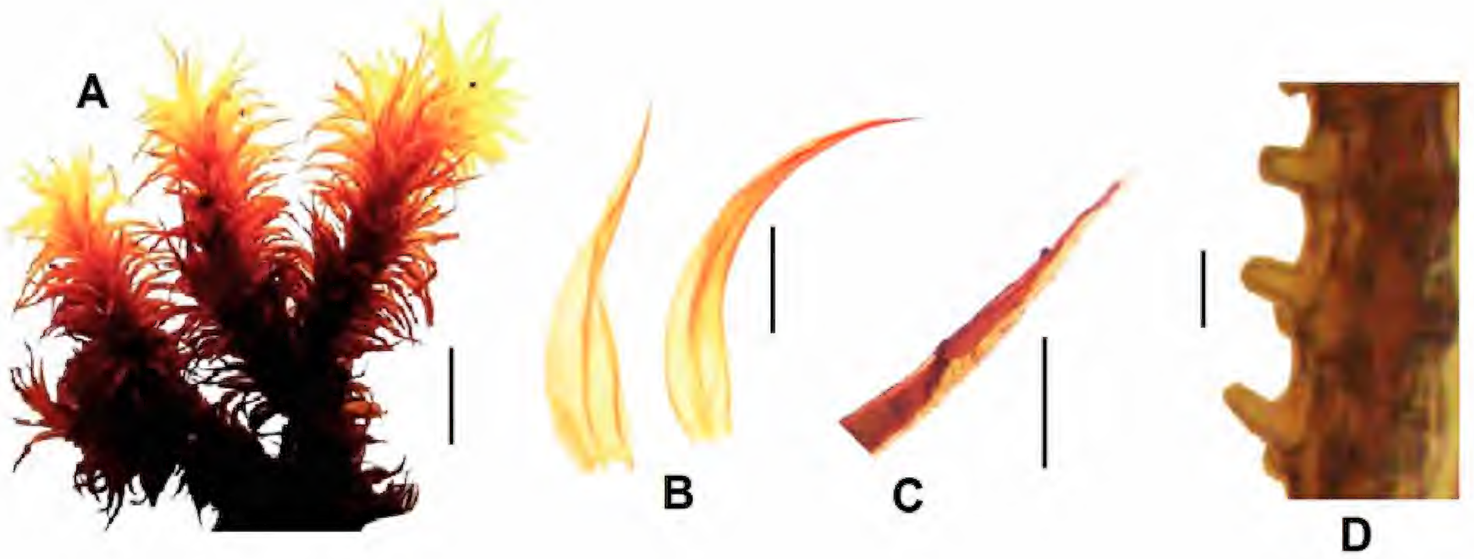

Fig. 2. *Macromitrium megalocladon* M.Fleisch. **A**: Habit of plant, moist. **B**: Leaves, adaxial view. **C:** Leaf apex, adaxial view. **D:** Papillae of leaf cells near the alar region. **E.** Upper leaf cells. **F.** Median leaf cells. **G:** Basal-marginal and alar region. **H.** Basal leaf cells. All from *E.L.R. Logatoc 20-0133* (CAHUP). Scale bars: A = 5 mm; B = 1 mm; C = 0.5 mm; D = 6 µm; E, F = 40 µm; G = 0.2 mm; H = 30 µm.

Macromitrium salakanum Müll.Hal., *Syn. Musc. Frond*. 2: 646. 1851. *Type*: Indonesia, Java, Mt Salak, *Zollinger 1426* (lectotype: L, designated by Vitt *et al.* 1995).

Macromitrium reflexifolium Sande Lac., *Verh. Kon. Akad. Wetensch., Afd. Natuurk*. 13: 8. 1872, *nom. illeg. Macromitrium celebense* Paris, *Index Bryol.* 773. 1897. *Macromitrium salakanum* subsp. *celebense* (Paris) M.Fleisch., *Musci Buitenzorg* 2: 446. 1908. *Macromitrium salakanum* var. *reflexifolium* M.Fleisch. ex E.B.Bartram, *Philipp. J. Sci.* 68: 179. 1939. *Type*: Indonesia, Sulawesi, Menado, *de Vriese s.n.* (lectotype: L, designated by Vitt *et al.* 1995).

Macromitrium salakanum var. *reflexifolium* M.Fleisch. *Die Musci der Flora von Buitenzorg* 2: 447. 1904, *nom. inval.*

Descriptions: Fleischer (1904: 442–445), Bartram (1939: 179), Vitt *et al.* (1995: 65–68), Eddy (1996: 52).

Illustrations: Fleischer (1904: 443, fig. 82), Vitt *et al.* (1995: 66, fig. 29a–j), Eddy (1996: 50–51, fig. 362).

Notes: *Macromitrium salakanum* are small, mat-forming plants characterised by the: narrowly lanceolate, squarrose-recurved leaves; branch leaves ending in either narrow apices or as short mucro with excurrent costa; smooth sigmoid-elongate basal cells gradually grading to obscure upper leaf cells; obtuse perichaetial leaves; and hairy calyptrae (Vitt *et al.* 1995). The species belongs to the *salakanum-angustifolium-incurvifolium* group, with the three species sharing the small habit, non-tuberculate basal cells, and obscure papillose upper leaf cells. *Macromitrium salakanum* is distinguished from the others by combining the squarrose-recurved leaves and obtuse perichaetial leaves about the same size as vegetative leaves.

The species is widely scattered in Malesia, having been recorded from the Philippines, Java, Sulawesi, and New Guinea, reaching New Caledonia and the Solomon Islands (Vitt *et al.* 1995; Eddy 1996). In the Philippines, *M. salakanum* was reported from Luzon, Mindoro, Palawan, Leyte, Camiguin, and Mindanao (Tan and Iwatsuki 1991; Tan 1996; Linis 2009).

Specimen examined: Palawan Island: Brooke's Point Municipality, Mt Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, *ca* 1000 m elev., on a fallen branch, 07 January 2020, *E.L.R. Logatoc 20-0071* (CAHUP, PPC, VBGI).

Macromitrium zollingeri Mitt. ex Bosch & Sande Lac., *Bryol. Jav*. 1: 113. 1859. *Type*: Indonesia, Java, *Zollinger 3716* (lectotype: L, *fide* Touw 2007).

Descriptions: Fleischer (1904: 422–424), Eddy (1996: 78), Guo *et al.* (2006: 476 as *M. blumei* var. *zollingeri*).

Illustrations: Fleischer (1904: 423, fig. 77), Eddy (1996: 77, fig. 384).

Notes: *Macromitrium zollingeri* are mat-forming plants that can be distinguished from other small to medium-sized Philippine *Macromitrium* species by: densely arranged, ligulate branch leaves with broadly-obtuse to rounded-truncate leaf apices; strongly and abruptly excurrent costa in branch leaves, forming a distinct awn; ovate-triangular and acuminate perichaetial leaves, with percurrent to excurrent costa; long seta; and naked calyptrae (Eddy 2006).

Guo *et al.* (2006) evaluated the taxonomic distinctness of *Macromitrium annamense* Broth. & Paris, *M. blumei*, and *M. zollingeri* based on statistical methods using the morphology of leaves and setae sampled from type specimens and other specimens. They suggested that *M. zollingeri* should be treated as *M. blumei* var. *zollingeri* (Mitt. ex Bosch & Sande Lac.) S.L.Guo, B.C.Tan & V.Virtanen. However, given the apparent cryptic diversity in the Orthotrichaceae, we treat this taxon as a distinct species until a thorough molecular investigation proves otherwise. *Macromitrium zollingeri* differs from *M. blumei* in having longer leaves with longer awns, ligulate leaf outlines with higher leaf length/width ratios, and acuminate perichaetial leaves.

Macromitrium zollingeri is a species widespread in Malesia (Eddy 1996), recorded from Indochina, the Malay Peninsula, Sumatra, Borneo, and Sulawesi (Tan and Iwatsuki 1993; Eddy 1996; Gradstein *et al.* 2005; Suleiman *et al.* 2006). Linis and Schwarz (2023) recently reported this species from the Philippines, particularly in Mt Apo, Mindanao Island.

Specimens examined: Palawan Island: Narra Municipality, Mt Victoria, mossy forest, on a branch of a hardwood tree, 19 February 2021, *M.D. delos Angeles s.n. [01]*, *M.D. delos Angeles s.n. [11]* (CAHUP).

Schlotheimia Brid.

Schlotheimia wallisii Müll.Hal., *Linnaea* 37: 173. 1873 [1872]. *Type*: Philippines, Insulae Philippinae regione montosa, *G. Wallis s.n.* (lectotype: NY, designated by Vitt *et al.* 1993).

Schlotheimia speciosissima Broth., *Philipp. J. Sci., C.* 3: 17. 1908. *Type*: Philippines, Mindanao, Misamis Province, Mt Malindang, *Mearns and Hutchinson For. Bur. 4798* (holotype: Forestry Bureau Manila Herbarium, destroyed).

Descriptions: Bartram (1939: 185–186), Vitt *et al.* (1993: 19–23), Eddy (1996: 88).

Illustrations: Vitt *et al.* (1993: 20, 8a–k), Eddy (1996: 86–87, fig. 389).

Notes: A common species throughout its range, *Schlotheimia wallisii* is a somewhat variable species that has been described under several names (Vitt *et al.* 1993). In Palawan, this species is distinguished from other species of Orthotrichaceae by: robust plants and leaves; erect-spreading and rugose leaves, when moist; leaves with intact long, flexuose arista; prorate basal leaf cells; long seta; smooth capsules; and very long calyptra (Vitt *et al.* 1993; Eddy 1996).

Schlotheimia wallisii is widely distributed in Malesia and adjacent areas (Vitt *et al.* 1993; Eddy 1996). In the Philippines, it is reported from Luzon, Mindoro, Negros, and Mindanao (Tan and Iwatsuki 1991; Tan and Mandia 2001). At Palawan, this species was collected on tree trunks and fallen branches in the tropical lower and tropical upper montane rainforests of Mt Mantalingahan, representing a new record for the island.

Specimens examined: Palawan Island: Rizal Municipality, Mt Mantalingahan, tropical upper montane rainforest-over-ultramafic substrate, *ca* 1600 m elev., on the trunk of a hardwood tree, 27 July 2019, *E.L.R. Logatoc 19-0310* (CAHUP, PPC, VBGI); Brooke's Point Municipality, Mt Mantalingahan, tropical lower montane rainforest-over-ultramafic substrate, *ca* 1200 m elev., on a fallen branch, 07 January 2020, *E.L.R. Logatoc 20-0080* (CAHUP, VBGI), *ca* 1300 m elev., on a fallen branch, 07 January 2020, *E.L.R. Logatoc 20-0099* (CAHUP, PPC, VBGI), tropical upper montane rainforest-over-ultramafic substrate, *ca* 1600 m elev., on the trunk of a hardwood tree, 08 January 2020, *E.L.R. Logatoc 20-0121* (CAHUP, VBGI).

Checklist of Orthotrichaceae from Palawan Island, the Philippines

List of 13 species of Orthotrichaceae currently known to occur in Palawan Island. An asterisk (*) indicates a new island record, while a double asterisk (**) indicates a new country record.

Desmotheca apiculata (Dozy & Molk.) Lindb. ex Cardot

**Groutiella tomentosa* (Hornsch.) Wijk & Margad.

**Macromitrium angustifolium* Dozy & Molk.

Macromitrium blumei Nees ex Schwägr.

***Macromitrium clemensiae* E.B.Bartram

Macromitrium cuspidatum Hampe

Macromitrium falcatulum Müll.Hal.

**Macromitrium fuscescens* Schwägr.

**Macromitrium incurvifolium* (Hook. & Grev.) Schwägr.

**Macromitrium longicaule* Müll.Hal.

***Macromitrium megalocladon* M.Fleisch.

Macromitrium salakanum Müll.Hal.

* *Macromitrium zollingeri* Mitt. ex Bosch & Sande Lac.

**Schlotheimia wallisii* Müll.Hal.

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Bush Blitz collections and iNaturalist observations assist the recognition of a new species from New South Wales, *Lomandra briggsiana* (Asparagaceae)

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Abstract

A new species of *Lomandra* Labill., *Lomandra briggsiana* R.L.Barrett & T.C.Wilson, is described from the Great Dividing Range and Western Slopes of New South Wales. The new species has affinity to the widespread south-eastern Australian species *Lomandra multiflora* (R.Br.) Britten, and to *L. decomposita* (R.Br.) Jian Wang ter & A.R.Bean and *Lomandra ramosissima* Jian Wang ter from Queensland. It has previously been included under *L. multiflora* as a 'terete-leaved' form in the *Flora of New South Wales* and recognised as *Lomandra* sp. Oxley Wild Rivers (T.M. Collins 924) on PlantNET. While the taxon has been known for some time, many of the existing collections are sterile or have only immature or old inflorescences present, and all but one of the collections represent only a single sex. Formal description has been prompted by the collection of fertile material during a Bush Blitz expedition in Oxley Wild Rivers National Park and good-quality photographs of flowering material posted on iNaturalist.

Introduction

Permanently preserved specimens held in accessible research collections provide a wealth of knowledge about our natural world. These records are evidence supporting both a contemporary and historical understanding of species distributions. However, it is not uncommon to find that some specimens represent species that are yet to be formally named. Bebber *et al.* (2010) estimated that of 50% of undescribed plant species are already represented in herbaria. This is indeed the case for the new species described here, with existing herbarium specimens dating back to 1949. Taxonomists have at times been criticised for 'overlooking' novel entities for such long periods of time. However, as in other categories of science, taxonomy is progressive and over time its hypotheses of relationships and species limits are tested by an increasing wealth of evidence. Advancing knowledge of defensible taxonomic boundaries therefore provides a foundation for targeted conservation action (Thomson *et al.* 2018), with newly recognised species often having restricted distributions and conservation requirements.

The mat rush genus *Lomandra* Labill. is exemplary of a group with many unresolved taxonomic problems, including undescribed entities and uncertainty regarding the appropriate taxonomic rank for currently recognised infra-specific taxa. This non-charismatic plant group has at least 60 species, all but two of which

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are endemic to Australia where they commonly inhabit woodland and heathland communities (Lee 1966; Lee & Macfarlane 1986; Quirico 1993; Conn 1994). Ten of these species have only been described in the last decade (Macfarlane & Conran 2015; Wang & Bean 2017; Barrett 2018; Wang 2018, 2021a, 2021b, 2023a, 2023b). *Lomandra* species are found across most of Australia, though only a few species occur in limited parts of the arid zone, with centres of diversity in both south-western and south-eastern Australia (Lee & Macfarlane 1986).

What makes *Lomandra* particularly difficult to identify is that its vegetative growth generally consists of rhizomatous shoots that produce above-ground strap-like or terete leaves, thereby leaving few readily-identifiable morphological characters for species delimitation in the absence of fertile material (Donnon 2009). There are some useful inflorescence and floral characters that require better quantification, including inflorescence branching patterns, floral bract arrangement, flower arrangement, flower shape, and tepal size, shape, and colour when fresh (Donnon 2009). Fruit might provide informative characters, but little is known of their taxonomic utility given that they seldom are present on herbarium specimens.

Complicating the taxonomy of *Lomandra* further is that most species are functionally dioecious, and despite many species appearing markedly different in inflorescence morphology, separate sexes are nearly indistinguishable by vegetative characters. Compared to male inflorescences, female inflorescences are quite inconspicuous because their flowers are usually sessile. Since most gatherings of *Lomandra* include only one sex, it appears that such a clear morphological difference may have led to mistaken assumptions that individuals of different sex were distinct species. Less-prominent female flowers may also be incorrectly interpreted by field collectors as immature and thus not collected.

Lomandra multiflora (R.Br.) Britten is a particularly widespread and variable taxon in eastern Australia, with two subspecies currently recognised (Lee & Macfarlane 1986). Members of this complex share a number of general similarities in appearance, including leaf apices that are ± entire, whorled branching in the inflorescence (each whorl usually many-flowered), and opposite, imbricate floral bracts (Lee & Macfarlane 1986; Wang & Bean 2017; Wang 2018). The usually flat (or sometimes concave) leaves are consistent throughout typical *L. multiflora* and also match other closely related species like *L. patens* A.T.Lee, a species with a much larger and more branched inflorescence found further inland than *L. multiflora*. However, there also exists a terete-leaved form noted in the *Flora of Australia* and *Flora of New South Wales* (Lee & Macfarlane 1986; Quirico 1993) and more recently recognised under the phrase name *Lomandra* sp. Oxley Wild Rivers (T.M. Collins 924) on PlantNET (2023), which appears to be restricted to New South Wales.

Historically, there have been few collections of this form to provide a rigorous taxonomic assessment of its status relative to *L. multiflora*. However, several collections were made on the Oxley Wild Rivers *Bush Blitz* Expedition in 2015, a program specifically aimed at new species discovery and documentation of biodiversity (see Barrett 2015; Preece *et al.* 2015). On this expedition, *Lomandra* sp. Oxley Wild Rivers was shown to co-occur with *L. multiflora*, with plants of both sexes collected for both species, and no observed evidence of introgression (A. Orme, pers. comm.). These field observations suggest genetic isolation between the two entities. The concept of *Lomandra* sp. Oxley Wild Rivers continued to mature when the authors acquired morphologically similar specimens from the serpentinite outcrops of Watchimbark Nature Reserve in 2018. Furthermore, its recognition is also assisted by the steadily growing observations of *Lomandra* on iNaturalist (2023, https://inaturalist.ala.org.au/), a citizen science platform that is increasingly being recognised for its utility with taxonomic research and discovery (Mesaglio *et al.* 2023; Webb *et al.* 2023). Observations of *Lomandra* sp. Oxley Wild Rivers posted on iNaturalist enabled assessment of floral characters from photographs, and guided collection of additional fertile specimens which were instrumental in describing the species for this paper. Some additional sterile, but atypical collections at NSW could be confidently excluded from this species concept following examination of iNaturalist records representing those populations.

Given the apparent paucity of macro-morphological characters useful for species relationships and species limits of *Lomandra*, an advanced taxonomy of *Lomandra* will likely benefit from molecular analysis paired with careful morphological study. At present only preliminary data are available that do not include multiple accessions of *L. multiflora* (see Donnon 2009; Gunn *et al.* 2020). However, recent unpublished work that was initiated in parallel with our morphological study has constructed a large molecular dataset using the Angiosperms353 bait capture set (Baker *et al.* 2022). Preliminary results indicate that *Lomandra* sp. Oxley Wild Rivers is recovered within the *Lomandra multiflora* complex. However, most relationships within the complex remain uncertain due to a lack of corresponding branch support (T.C.Wilson, R.L.Barrett, J.L.Birch & B.F.Gunn, unpubl. data).

In this paper we describe a new species, *Lomandra briggsiana* R.L.Barrett & T.C.Wilson based on our morphological examination of *L.* sp. Oxley Wild Rivers (T.M. Collins 924). Given evidence is restricted, we circumscribe it as a distinct species based primarily on the unique leaf morphology consistent between female and male plants relative to other entities in the *L. multiflora* complex.

Methods

This description is based on measurement of herbarium specimens held at CANB and NSW. Field observations of *L. briggsiana* R.L.Barrett & T.C.Wilson have been made by the authors. Terminology and the layout of the description follows Wang and Bean (2017) and Wang (2018). Illustrations are based on photographs of live plants and from herbarium material at NSW.

Taxonomy

Lomandra briggsiana R.L.Barrett & T.C.Wilson, *sp. nov.*

Type: New South Wales: Hunt's property, 'Kilmarnoc', between Attunga and Halls Creek, 11 Sept. 1996, *J.R. Hosking 1289* (holo: NSW 597650 (♀); iso: CANB 533038.1, CANB 533038.2, MEL 0285175, NE 66058, NSW 597651).

Lomandra sp. Oxley Wild Rivers (T.M. Collins 924)

Plants robust, perennial, forming tussocks from condensed erect ramets, rhizome vertical (taproot-like), 4.5–16 mm diam. Each tussock comprising 1–5 poorly distinguished tufts (ramets). Leaves firm, erect to slightly curved. Leaf sheath white to cream, margins at first membranous, fraying into short to long strips or fibres up to 4.5 cm long, translucent, white. Leaf blades glaucous, smooth, usually terete (sometimes slightly compressed) for most of their length, but partially flattened above in the sheathing portion and rarely above the sheath on some leaves, 17–47 cm long, 0.9–1.4(–1.7) mm wide, with 22–30 parallel veins; apex acute to pungent, without teeth; the margins of the sheathing portion slightly thickened and smooth or sometimes minutely serrulate. Male inflorescences 1–4 per plant, usually a 1-branched panicle with numerous flower clusters, rachis and scape elongating with age; scape 2–13.5 cm long, 0.5–1.4 mm wide, subterete to compressed, smooth to minutely verrucate; rachis often angled, minutely verrucate; branches and flower clusters appearing whorled or opposite at nodes; the primary rachis 3.5–18.5 cm long, the secondary rachis usually 1–3 cm long. Cluster bracts usually 5–7, with 1 or 3 obvious veins, narrowly triangular, 2–3.5(–7) mm long, 1–1.5 mm wide at the base, largest at the basal node of primary rachis, shorter and narrower distally. Flowers in groups of 4–17, each subtended by usually 3 bracteoles, *c.* 1.2 mm long and 0.8 mm wide, membranous, completely encircling the flower base, pedicellate, the pedicels 3.2–5.9 mm long, 0.15 mm wide, similar ages within each cluster; outer 3 tepals broadly elliptical, thin, free, somewhat cucullate, uniform in size and texture, 2.2–2.6 mm long, *c.* 1.2 mm wide, adnate at the base; inner 3 tepals narrow-ovate, not cucullate, 2.3–2.8 mm long, *c.* 1.0 mm wide, adnate near base. Pistillode poorly developed, *c.* 0.1 mm long, pale yellow. Female inflorescence 1 per ramet, paniculate, much shorter than longest leaf; the peduncle ± terete (angular when dried), smooth to minutely verrucate, 2–4 cm long, usually 0.3–0.8 mm diam., greenish to cream; the primary rachis ± terete and smooth or finely ribbed, or 5-angled when dry, smooth to minutely verrucate, 2–8 cm long, not branched, with 3–9 flower clusters, appearing whorled at nodes, the flowers in groups of 10–24 in each cluster, all of similar age within each cluster; flower clusters 0.5–1 cm apart on the rachis. Cluster bracts usually 3 or 4, short-deltoid, up to 2 mm long, *c.* 1 mm wide at the widest point, with 1 or 3 obvious veins, largest at the basal node of rachis, shorter and narrower upwards along rachis. Bracteoles 3, ± cucullate, but apex divided, so appearing broadly obsagittate in outline, apices subacute, *c.* 1.2 mm long and 1 mm wide, membranous, completely encircling the pedicel. Flowers subsessile, pedicels to 0.6(–1.2) mm long, hidden by bracts. Flower buds obovoid, purplish brown, at anthesis becoming campanulate, creamy-yellow to yellow. Perianth segments 6, with distinct outer and inner whorls; outer tepals 3, broadly elliptical, thin, free, somewhat cucullate, uniform in size and texture, 2.1–2.5 mm long, 1.0–1.1 mm wide, pale yellow with a broad purplish-brown mid-stripe; inner tepals 3, elliptical, free except on lower 1/4, not cucullate, uniform in size and texture, 2.2–2.7 mm long, 0.7–0.8 mm wide, creamy yellow. Stamens 6, adnate basally to the inner tepals, the filament often connate to the inner tepals for most of its length; anthers all similar, 0.5–0.55 mm long, 0.3–0.4 mm wide, creamy yellow; anthers of inner tepals slightly more distal than the antetepalous anthers. Staminodes 6, whitish-transparent, with well-developed filaments and vestigial anthers, inserted on basal part of tepal, adnate for 1/2 length. Pistil conspicuous, the ovary obovoid, *c.* 0.8 mm long, *c.* 0.6 mm diameter; styles fine, fused, with 3 minute out-curved stigmatic lobes; ovary with 3 locules; ovules 1 per loculus. Fruit not seen. (Figures 1–4)

Fig. 1. *Lomandra briggsiana* at Dunedoo. A. Habitat. B. Habit. C. Male flowering plant. D. Female plant with old inflorescences. E. Plant base with old female inflorescences. F. Terete, glaucous leaves. G. Leaf sectioned by secateurs. H. Clasping leaf base. I. leaf base (left) and young apex (right). J. Male inflorescence. Photos: A, D–I by Russell Barrett (voucher: *R.L. Barrett et al. RLB 9477*); B by Anthony O'Halloran; C, J: by Anne Kable (also posted on iNaturalist 59760073).

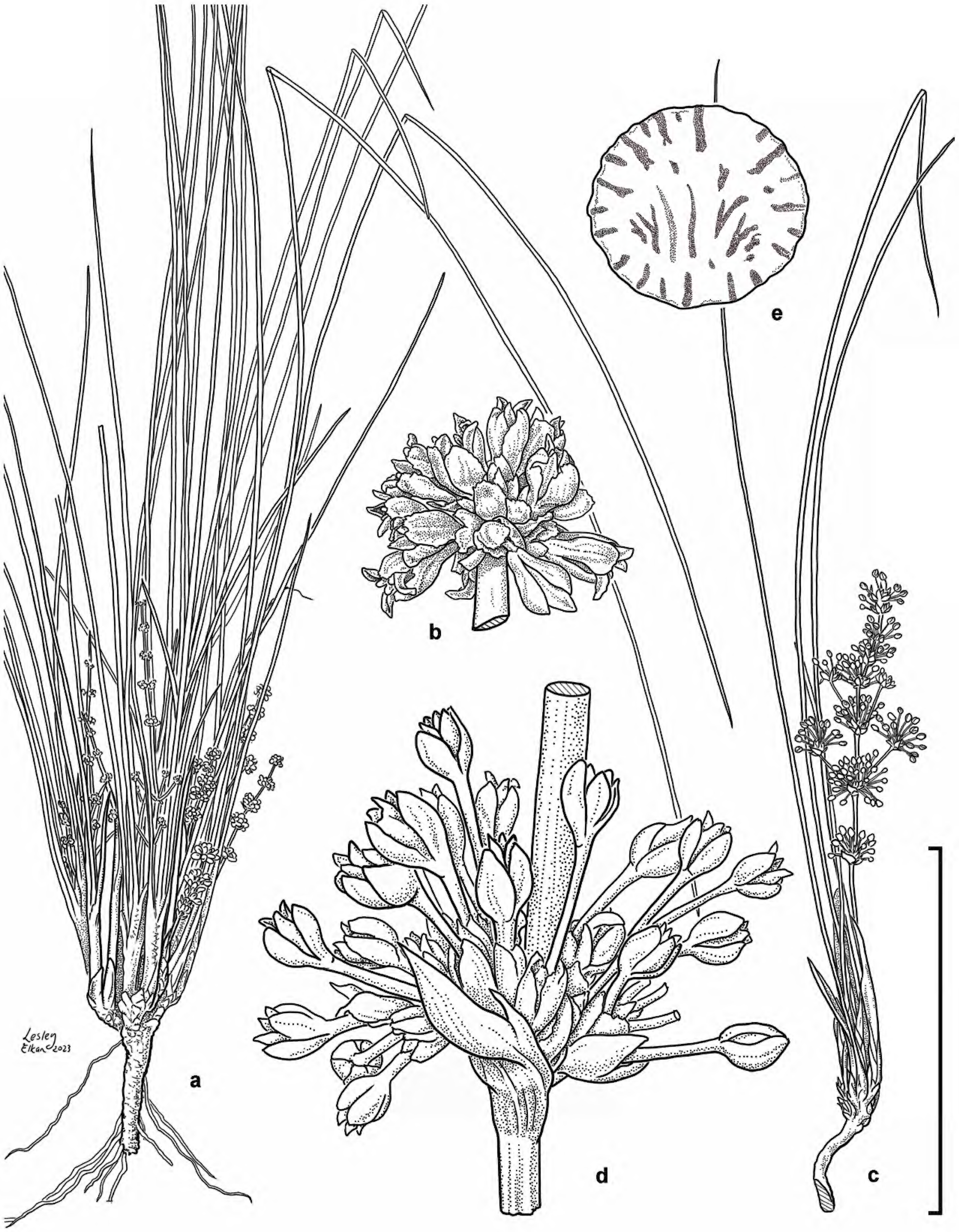

Fig. 2. *Lomandra briggsiana*. A. Habit of female plant with inflorescence. B. Female inflorescence. C. Habit of male plant with inflorescence. D. Male inflorescence. E. Transverse section of a leaf. Vouchers: A, B, *J.R. Hosking 1289* (NSW 597650); C, D, *V. Klaphake 1229* (NSW 395354); E, *R.L. Barrett et al. RLB 9477* (NSW). Scale bars: A, C = 10 cm; B, D = 1 cm; E = 3.3 mm. Illustration by Lesley Elkan.

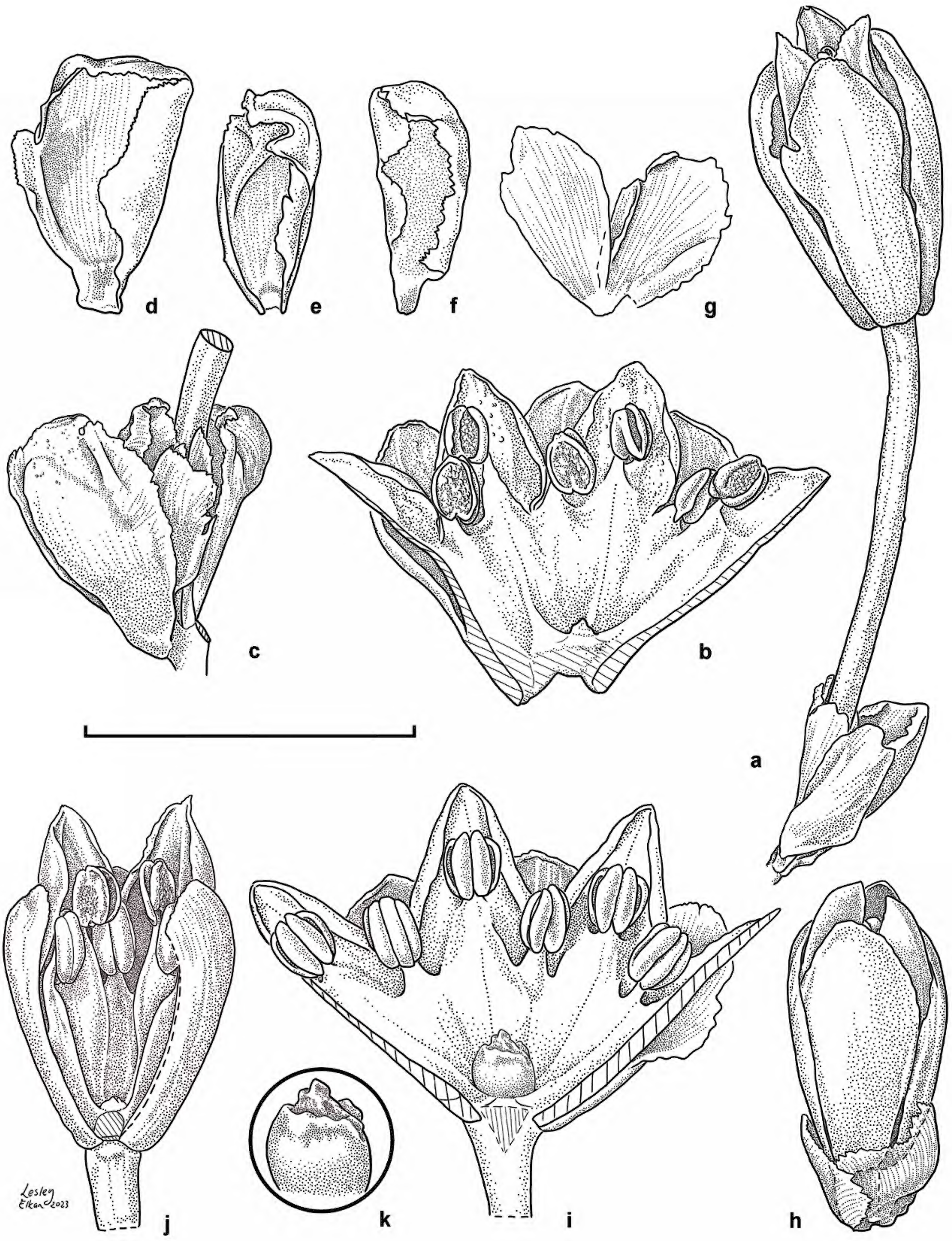

Fig. 3. *Lomandra briggsiana*. A–G, Male Flower. A. Flower with pedicel and bracts. B. Openly dissected flower. C. Bract arrangement around pedicel of male flower. D–G. Floral bracts. H–K, Female flower. H. Female flower. I. Open flower. J. Flower with one tepal removed. K. Ovary and stigma detail. Vouchers: A, B: *M.F. Duretto 4124*; C–G: *R.L. Barrett et al. RLB 9477*; H–J: *J.R. Hosking 1289*; K (and inserted within I): *R. Coveny 9215* (all NSW). Scale bars: A–J = 3 mm. K = 1.8 mm. Illustration by Lesley Elkan.

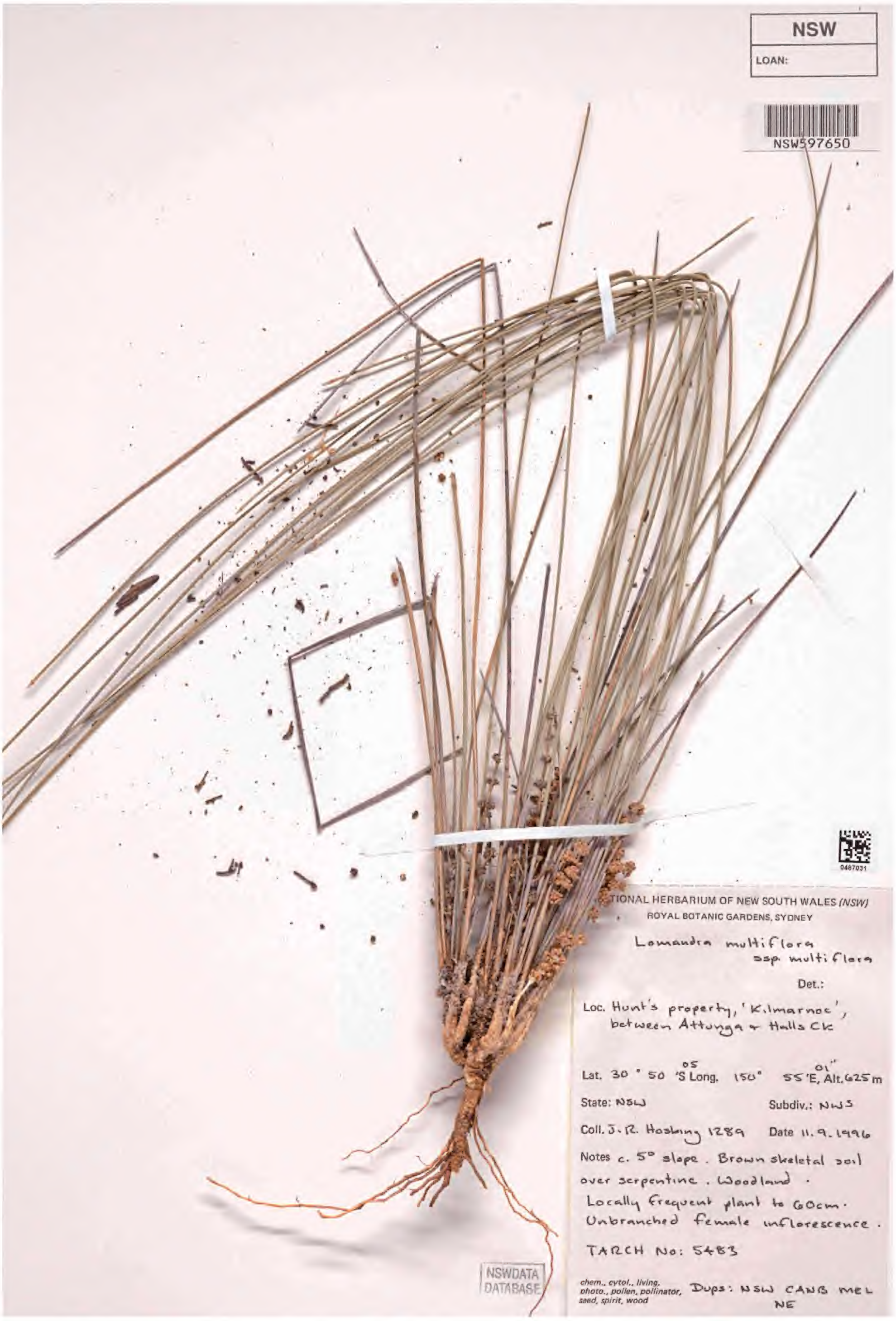

Fig. 4. Holotype of *Lomandra briggsiana*, *J.R. Hosking 1289* (NSW 597650).

Diagnostic characters: Differs from *Lomandra multiflora* by its terete (*vs* flat to concave), glaucous (*vs* green) leaves with an undivided (*vs* toothed), often pungent (*vs* usually blunt) apex, and its erect (*vs* lateral) rhizomes. Differs from *L. decomposita* (which does have glaucous leaves) in its terete (*vs* convex or inrolled) leaves 0.9–1.4(–1.7) (*vs* 2.3–4.5(–6.5)) mm wide. Differs from *L. ramosissima* by its white to cream (*vs* reddish to dark brown) coloured leaf sheaths and terete leaves 0.9–1.4(–1.7) mm wide (*vs* flat to convex leaves 2.5–5 mm wide).

Specimens examined: NEW SOUTH WALES: Watchimbark Nature Reserve, 23 Jan. 2018, *R.L. Barrett, M.A.M. Renner, H. Sauquet, P. Weston & T.C. Wilson RLB 9121* (NSW); Old Cemetery Reserve, Dunedoo, 6 Apr. 2022, *R.L. Barrett, Z.E. Davies, X.V. Davies & F.F. Barrett RLB 9477* (AD, MEL, NSW); Coulsons Creek, foot of Liverpool Range, N of Merriwa, 28 Sept. 1968, *B.G. Briggs 2204* (♂) (NSW); Spring Creek gorge rim, *c.* 800 m from head of gorge, Oxley Wild Rivers National Park, 6 Nov. 2015, *T.L. Collins 924* (NSW); *c.* 60 km WNW of Armidale, along creekline in NW section of reserve, Stony Batter Creek Nature Reserve, 21 Nov. 2001, *L.M. Copeland 3265* (♀) (BRI, CANB, MEL, NE, NSW); Glen Alice, 7 Apr. 1977, *R.G. Coveny & P.D. Hind 9215* (♂) (NSW); West Cookeys Plains State Forest, Yarrabundi, 22 July 1976, *G.M. Cunningham & P.L. Milthorpe* (per *R.J. Turner*) *4713* (CANB); S side of Yarrowitch River Gorge, Oxley Wild Rivers National Park, 11 Nov. 2015, *M.F. Duretto 4112* (NSW); N of Yarrowitch Falls, Oxley Wild Rivers National Park, 11 Nov. 2015, *M.F. Duretto 4124* (♂) (NSW); N of Yarrowitch Falls, Oxley Wild Rivers National Park, 11 Nov. 2015, *M.F. Duretto 4125, T.L. Collins & A.E. Orme* (NSW); Oxley Wild Rivers National Park, 11 Nov. 2015, *M.F. Duretto 4126* (NSW); 3 km N Willows, *c.* 46 km NW of Glen Innes, Bonshaw Road, 5 Apr. 1995, *J.T. Hunter 2971* (NSW 470815); Crown Creek, 8 km by road S of Capertee–Glen Davis road, 2 km SE of Pantoneys Crown, Wollemi National Park, 19 Sept. 1995, *V. Klaphake 1229* (♀, ♂) (NSW); Western Way / F Line Rd, Merriwindi State Forest, 2 Oct. 1986, *D.F. Mackay s.n.* (♀) (NE, *n.v.*, NSW 597656); Old Cemetery Reserve, Dunedoo, 27 Sept. 2020, *A. O'Halloran s.n.* (BRI, CANB, NE, NSW); Browns Lane, near Kandos May 1998, *H. Washington s.n.* (♀) (NSW 1059550); 'Watervale', Capertee Valley, Block 2, 6 May 2000, *H. Washington s.n.* (♀) (NSW 597504); Mudgee district, Oct. 1949, *K. Watts s.n.* (♂) (NSW 66113); Bullock Creek *c.* 72 km E of Armidale, 19 Mar. 1970, *J.B. Williams s.n.* (♂) (MEL, NSW 597866).

iNaturalist observation: https://inaturalist.ala.org.au/observations/59760073

Distribution and habitat: Known from scattered collections between the Capertee Valley, Dunedoo, Tamworth and Barrington Tops, New South Wales (Figure 5).

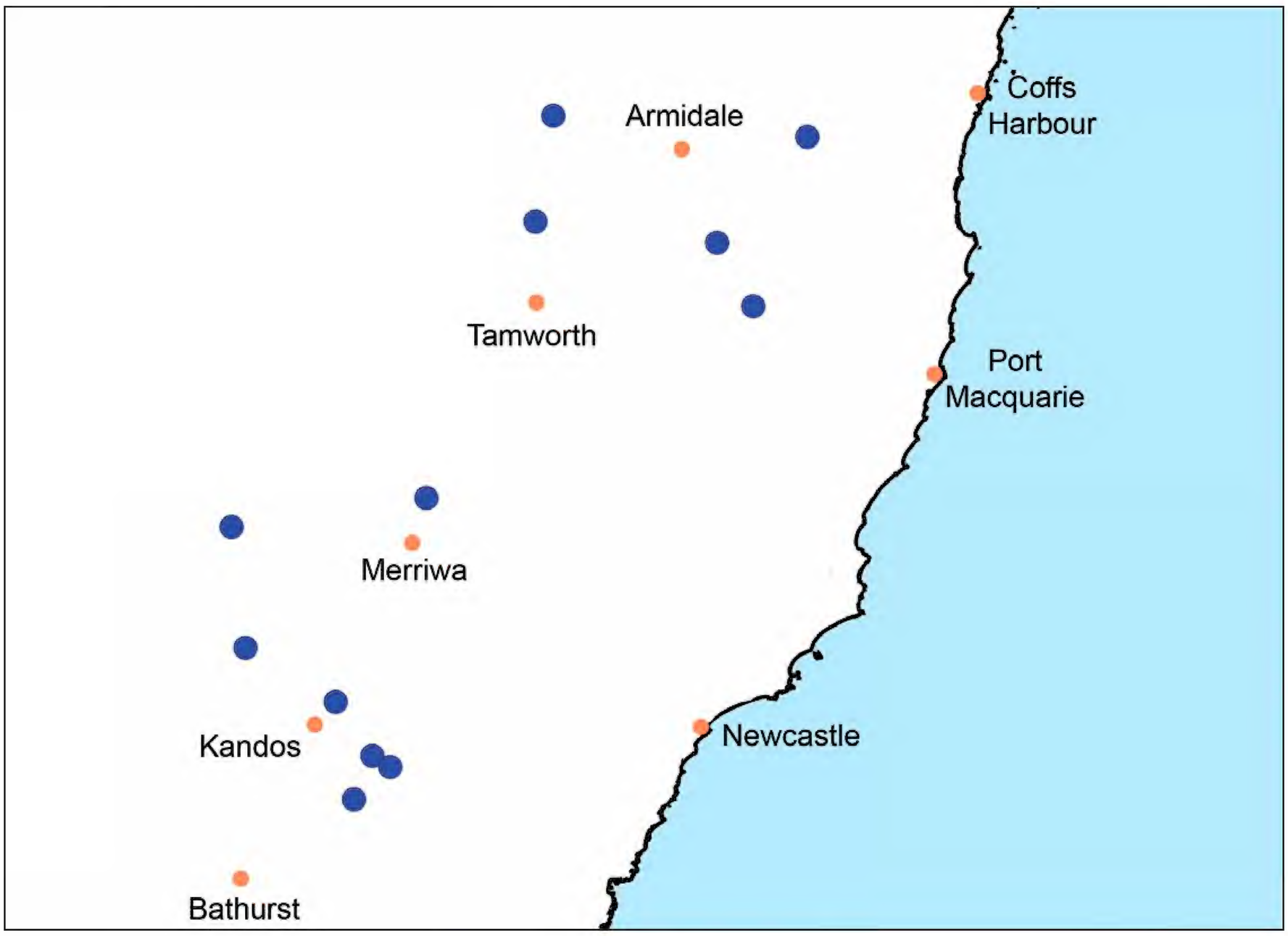

Fig. 5. Distribution map for *Lomandra briggsiana* (●). Map derived from Australia's Virtual Herbarium (http://avh.ala.org.au; accessed 3 May 2023).

Recorded from a wide variety of habitats on sandstone, granite, clays and serpentinite, on ridges, gentle slopes and in steep gorges, usually in Eucalypt woodland with a shrubby understory, but also in low heath communities. Grows in association with *Acacia difformis*, *A. implexa*, *A. ixiophylla*, *A. serpentinicola*, *Allocasuarina luehmannii*, *A. littoralis*, *A. ophiolitica*, *Angophora floribunda*, *Brachyscome procumbens*, *Bursaria spinosa*, *Callitris glauca*, *Calytrix tetragona*, *Dampiera adpressa*, *Eremophila mitchellii*, *Eucalyptus albens*, *E. andrewsii*, *E. bridgesiana*, *E. crebra*, *E. moorei* subsp. *serpentinicola*, *E. pilligaensis*, *E. prava*, *E. rubida*, *E. rossii*, *Grevillea granulifera*, *Hovea cymbiformis*, *Hovea lorata*, *Leionema* sp., *Lepidosperma laterale*, *Leptospermum brevipes*, *L. divaricatum*, *Lomandra multiflora*, *Muehlenbeckia rhyticarya*, *Philotheca difformis* subsp. *difformis*, *Pomaderris andromedifolia* subsp. *andromedifolia*, *P. brunnea*, *Templetonia stenophylla* and *Westringia cheelii*.

Phenology: Flowering recorded for August–November. Fruiting not observed.

Conservation status: This species is known from eleven locations including Wollemi National Park, Watchimbark Nature Reserve and Goonoo State Forest. The species is easily overlooked and is probably more common than current collections indicate. IUCN: Least Concern.

Etymology: The epithet honours the work of Barbara Gillian Briggs AM, for a lifetime's work on the Australian flora and for inspiring multiple generations of botanists. This is one of many novel species she collected during a long career of quiet yet globally significant achievements.

Notes: Confirmed by molecular data (T.C.Wilson, R.L.Barrett, J.L.Birch & B.F.Gunn, unpubl.) to be most closely related to *Lomandra multiflora*, *L. decomposita* and *L. ramosissima*, differing from all of these species by the combination of its terete, glaucous leaves 0.9–1.4(–1.7) mm wide and a distinctive, erect rhizome.

Collections from the southern part of the range are all sterile or immature. However, it may be that they have consistently shorter inflorescences with longer branches as indicated by the available herbarium specimens, or this may be an artefact of maturity stage. In any case, further collections from across the range of the species are desirable to assess possible variation within this species.

Table 1. Distinctive characters for taxa allied to *Lomandra multiflora* based on Lee & Macfarlane (1986), Quirico (1993), Conn (1994), Wang & Bean (2017) and Wang (2018).

Taxon	*L. multiflora* subsp. *multiflora*	*L. multiflora* subsp. *dura*	*L. patens*	*L. decomposita*	*L. ramosissima*	*L. briggsiana*
Rhizome	lateral	lateral	lateral	lateral	semi-erect	erect
Leaf sheath	white, purplish or brown	White to pale brown	white, grey or brown	white or pale to dark brown	reddish to dark brown	white to cream
Leaf blade	green or greyish green	greyish green	green	glaucous	glaucous	glaucous
Leaf shape	flat or slightly concavo-convex	flat or slightly concavo-convex	concavo-convex	slightly convex or inrolled	flat or slightly convex	± terete
Leaf width	1.5–4.5 mm	2–4.5 mm	2.5-4.5 mm	2.3–4.5(–6.5) mm	2.5–5 mm	0.9–1.4(–1.7) mm
Inflorescence branching	1–3	1 or 2	2–3	1–3(–4)	1–3(–4)	1 or 2
Male flowers per whorl	8–22	5–15	3–12	4–15(–25)	6–14	4–17
Male pedicel length	3–8(–12) mm	0(–2) mm	0–1 mm	1.5–2.5(–3.5) mm	1–1.5(–2) mm	3.2–5.9 mm
Male inner tepal length	2.5–3.5 mm	2.1–3.0 mm	4–6 mm	1.1–1.2 mm	2.5–2.9 mm	2.3–2.8 mm
Female pedicel length	sessile	sessile	sessile	c. 0.5 mm	0.3–0.5(–1.5) mm	0.6(–1.2) mm
Female inner tepal length	c. 4.5 mm	2–3 mm	2.9–3.5 mm	c. 3 mm	c. 3.2 mm	2.2–2.7 mm
Capsule length	c. 6 mm	c. 5 mm	4.5–6.1 mm	7.5–8 mm	4–5 mm	not known

Modification to the PlantNET key to *Lomandra* species in New South Wales

10. Tepals divided to base 10A

10: Tepals fused in lower half 12

10A. Rhizomes erect; leaves terete, 0.9–1.4(–1.7) mm diam., glaucous, apex often pungent..... ***L. briggsiana***

10A: Rhizome lateral; leaves flat or slightly concavo-convex or inrolled, 1.5–4.5 mm wide, green or greyish green, apex obtuse 11

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Molecular phylogenetic study of *Utricularia* section *Oligocista* in Australia and a new Cape York endemic species

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Abstract

*Utricularia s*ection *Oligocista* A.DC. (Lentibulariaceae) is distributed across the old and new world tropics. We present a molecular phylogeny using a matrix of the nuclear ITS and two chloroplast markers that includes 19 of the 37 recognised species sampled across the range of each species. The phylogenetic study also includes members of the closely allied sections *Enskide* (Raf.) P.Taylor (including section *Minutae* Lowrie, Cowie & Conran) and *Stomoisia* (Raf.) Kuntze from across each of their distributions. The phylogeny shows that Australia contains species from the two major clades of section *Oligocista*, with each involving ancestors with yellow and purple/mauve corolla colours. This study provides morphological and molecular evidence for recognition of a new species, *Utricularia irwinica* R.W.Jobson & Baleeiro, from Cape York Peninsula, Queensland. A lectotype is designated for the name *Utricularia cyanea* var. *alba* Benth. We also recommend changes to the taxonomy of sections *Enskide* and *Oligocista* based on the phylogenetic results and morphology.

Introduction

*Utricularia s*ection *Oligocista* A.DC. was circumscribed by Taylor (1989) containing 37 species distributed across the old and new world tropics with the majority found in Asia (14 spp.), followed by Africa and Madagascar (10 spp.), America (7 spp.) and Australia (5 spp.). Since Taylor (1989), six species have been described for Asia (Janarthanam & Henry 1989, 1990, 1992; Parnell 2005; Suksathan & Parnell 2010; Yadav et al. 2005), and one from the Neotropics (Souza & Bove 2011). The type for the section is *U. bifida* L., a small, yellow-flowered species from Asia and northern Australia/Papua New Guinea (Taylor 1989). The current study used plastid and nuclear markers to reconstruct the molecular phylogeny of sect. *Oligocista* to understand the biogeography of the Australian species. One of these species, *Utricularia uliginosa* Vahl, is morphologically variable and distributed across tropical and northern Asia, Malesia, and Australasia. Sampling included the known distribution of this species, the putatively allied white-flowered form known as *U*. sp. Steve Irwin Reserve (R.W.Jobson 4153) from western Cape York Peninsula, and the closely related *U. praeterita* P.Taylor that is endemic to India (Taylor 1989; Janarthanam & Henry 1992; Kolte et al. 2019). Comparisons with closely related species, *U. praeterita*, and Asian/Oceanian *U. uliginosa* are provided. Diagnostic features are illustrated, and distribution, habitat, and conservation status are discussed.

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Methods

Taxon sampling and DNA extraction

Dried and alcohol-preserved material representing all available sect. *Oligocista* and related species were examined. These are held at the National Herbarium of New South Wales (NSW), Northern Territory Herbarium (DNA), Australian National Herbarium (CANB), Queensland Herbarium (BRI), Herbarium of IRD Nouméa (NOU), and Universidade de São Paulo (SPF).

We newly sequenced 48 accessions across sections *Oligocista/Enskide/Stomoisia* including a broad sampling of the widespread *U. uliginosa* (Table 1). Plant tissue was obtained from silica-dried and herbarium-sheet material. Based on the phylogeny of *Utricularia* by Jobson et al. (2003), five outgroup samples were selected from GenBank to represent the sister clade within the genus (Table 1). DNA isolation was performed as for Jobson et al. (2017). The final dataset contained 74 accessions of which 26 were previously published (Table 1).

Amplification and sequencing

Sequence amplifications used parameters for the nuclear ITS marker according to Jobson et al. (2022) and for the non-coding plastid markers (cpDNA) *rps*16 intron and *trn*D–*trn*T intron spacer (*trnD–T*) according to Shaw et al. (2005). The nuclear ribosomal ITS region was amplified for several difficult samples using the forward primer ITS5A (Stanford et al. 2000) and the universal internal reverse primer ITS2, and reverse primer ITS4 and internal primer ITS3 (White et al. 1990). Polymerase chain reaction (PCR) conditions for ITS were performed as described in White et al. (1990).

Phylogenetic analyses

Phylogenetic analyses were performed on datasets for each of the three individual markers as well as a concatenated matrix from all three markers combined. The most suitable nucleotide substitution model for each of the three markers was assessed using the Akaike information criterion (AIC) implemented in jModelTest (ver.2.1.7, see https://en.bio-soft.net/tree/MODELTEST.html, accessed 20 April 2023; Guindon and Gascuel 2003; Posada 2008). The best fit was GTR+ I+G (*rps16, trnD-T*) and GTR+G (ITS) with a burn-in involving the first 25% of the sampled trees. We estimated Bayesian posterior probability with five independent runs of 20 million generations using four chains each sampling a tree every 1000 generations. All parameters were set as Dirichlet with a flat multinomial distribution. Stationarity was assessed by examining plots of the –lnL across generations in Tracer (ver. 1.7, Rambaut *et al.* (2018), see http://beast.bio.ed.ac.uk/Trace, accessed 20 April 2023). The effective sample size (ESS) was set to >1000, and the remaining trees were used to construct a 50% majority rule consensus tree that was visualised using FigTree (ver. 1.4.4, http://tree.bio.ed.ac.uk/software/figtree, accessed 25 April 2023).

Results

Sequences and alignment

The *rps16* matrix was 1108 bp long, of which 301 characters (27%) were parsimony informative, *trnD-T* matrix was 935 bp long, of which 181 characters (19%) were parsimony informative, and the ITS matrix was 786 bp long of which 230 characters (29%) were parsimony informative. The three datasets included accessions of *rps16* (n = 66), *trnD-T* (n = 37), ITS (n = 33) (Table 1). The concatenated three gene matrix contained 68 ingroup and six outgroup taxa and was 2829 bp long with 712 parsimony informative characters (25%).

Phylogenetic relationships

The *rps16*, *trnD-T* and ITS datasets were analysed separately and resulting trees were largely topologically congruent, particularly across clade C (Fig. 1; Table 1). The 50% consensus tree consisted of two major clades provided with strong posterior probability support (PP = 1).

Section *Enskide* and sect. *Minutae* together formed a strongly supported clade, but sect. *Enskide* was found to be paraphyletic due to inclusion of sect. *Minutae* (Fig. 1). Section *Stomoisia*, sect. *Enskide* and sect. *Minutae* together formed a clade sister to a strongly supported sect. *Oligocista*. Section *Oligocista* was found to be paraphyletic due to the inclusion of monotypic sect. *Benjaminia* (Fig. 1). To accommodate these new relationships, we provide recommendations for sectional recircumscription below.

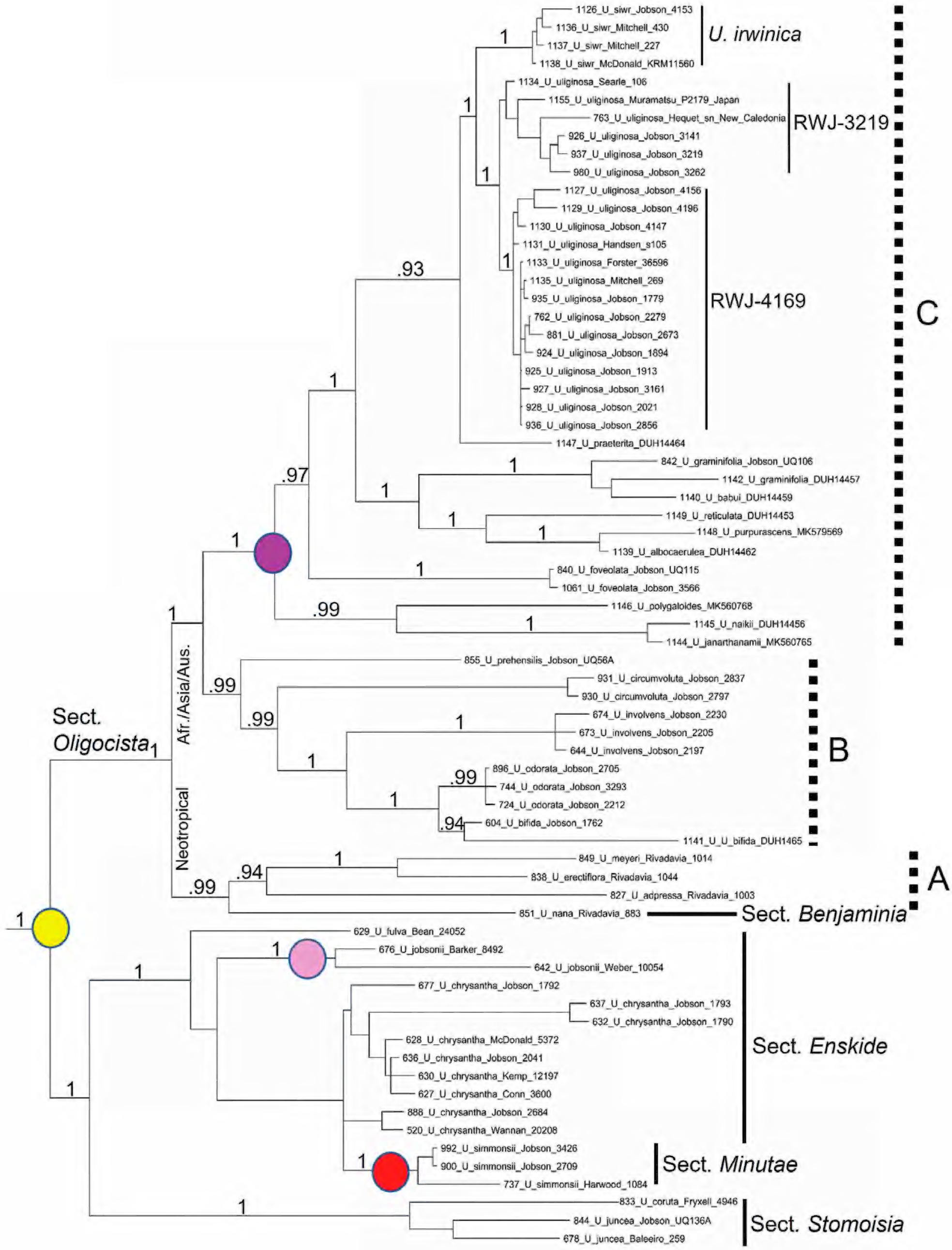

Fig. 1. 50% majority-rule Bayesian inference consensus tree for concatenated cpDNA/ITS data. Posterior probability (PP) support values are shown above important branches. PP = 0.95–1.00: strong support; 0.84–0.94: weak support (not shown); unsupported (not shown). Thin bars show two clades of *U. uliginosa* (RWJ-3219, RWJ-4196 – refer to Fig. 5) and the new species *U. irwinica*. Thick bars show sectional delimitations other than *Oligocista*. Three major clades of section *Oligocista* (A–C) shown behind broken lines. Character state transitions for corolla colour shown on relevant nodes (coloured circles).

Table 1. Accessions used in the nuclear (ITS) and cpDNA (rps16, trnDT) matrices. Secondary collectors are not included. Locality abbreviations: NSW, New South Wales; NT, Northern Territory; Qld, Queensland; WA, Western Australia. GenBank accession numbers for each sequence are shown. NS indicates sequencing failed or not carried out. GenBank numbers not preceded by "OR" are previously published. 'Code' refers to specimen number.

CODE	Section	Taxon	Collector	Coll. Date	Location	ITS	*RPS16*	*TRNDT*
520	*Enskide*	*U. chrysantha* R.Br.	Wannan 20208 (DNA)	6/05/1987	Jabiru, NT	NS	NS	OR141444
627	*Enskide*	*U. chrysantha* R.Br.	Conn 3600 (NSW)	14/06/1995	Hope Vale, Qld	NS	OR141359	OR141460
628	*Enskide*	*U. chrysantha* R.Br.	McDonald 5372 (BRI)	24/06/2006	Starke National Park, Qld	NS	OR141360	OR141461
629	*Enskide*	*U. fulva* F.Muell.	Bean 24052 (BRI)	4/06/2005	Humpty Doo, NT	NS	OR141361	OR141462
630	*Enskide*	*U. chrysantha* R.Br.	Kemp 12197 (BRI)	8/06/1997	North Kennedy, Qld	NS	OR141362	NS
632	*Enskide*	*U. chrysantha* R.Br.	Jobson 1790 (NSW)	21/04/2013	Mt Tozer, Qld	NS	OR141363	OR141463
636	*Enskide*	*U. chrysantha* R.Br.	Jobson 2041 (NSW)	16/09/2013	Hope Vale, Qld	NS	OR141364	OR141464
637	*Enskide*	*U. chrysantha* R.Br.	Jobson 1793 (NSW)	21/04/2013	Lockhart River, Qld	NS	OR141365	OR141465
642	*Enskide*	*U. jobsonii* Lowrie	Weber 10054 (AD)	3/06/1988	Murgenella, NT	NS	OR141366	OR141466
676	*Enskide*	*U. jobsonii* Lowrie	Barker 8492 (AD)	26/05/2004	Timber Creek, NT	NS	OR141370	NS
677	*Enskide*	*U. chrysantha* R.Br.	Jobson 1792 (NSW)	21/04/2013	Mt Tozer, Qld	NS	OR141371	NS
888	*Enskide*	*U. chrysantha* R.Br.	Jobson 2684 (NSW)	17/04/2015	Pine Creek, NT	NS	OR141395	OR141476
900	*Enskide*	*U. simmonsii* Lowrie et al.	Jobson 2709 (NSW)	20/04/2015	Girraween, NT	NS	OR141401	NS
992	*Enskide*	*U. simmonsii* Lowrie et al.	Jobson 3426 (NSW)	17/05/2017	Lorrela Station, NT	NS	OR141416	OR141494
604	*Oligocista*	*U. bifida* L.	Jobson 1762 (NSW)	20/04/2013	Lockhart River, Qld	NS	OR141343	NS
644	*Oligocista*	*U. involvens* Ridley	Jobson 2197 (NSW)	18/04/2014	Pine Creek, NT	NS	OR141367	NS
673	*Oligocista*	*U. involvens* Ridley	Jobson 2205 (NSW)	18/04/2014	Kakadu Hwy, NT	OR142164	OR141368	NS
674	*Oligocista*	*U. involvens* Ridley	Jobson 2230 (NSW)	20/04/2014	South Alligator River, NT	NS	OR141369	NS
724	*Oligocista*	*U. odorata* Pellegrin	Jobson 2212 (NSW)	19/04/2014	Jabiru, NT	NS	OR141383	NS
744	*Oligocista*	*U. odorata* Pellegrin	Jobson 3293 (NSW)	2/05/2011	South Alligator River, NT	NS	OR141387	NS
762	*Oligocista*	*U. uliginosa* Vahl	Jobson 2279 (NSW)	26/04/2014	Mitchell Plateau, WA	OR142165	OR141388	OR141470
763	*Oligocista*	*U. uliginosa* Vahl	Hequet sn (NOU)	1/07/2014	Noumea, New Caledonia	OR142166	OR141389	OR141471
827	*Oligocista*	*U. adpressa* Salzm. ex A.St.Hil.	Rivadavia 1003 (SPF)	1/05/1999	de Goias, Brazil	AF482509	AF482555	NS
838	*Oligocista*	*U. erectiflora* A.St.Hil. & Girard	Rivadavia 1044 (SPF)	3/05/1999	Goias, Brazil	NS	AF482568	NS
840	*Oligocista*	*U. foveolata* Edgew.	Jobson UQ115 (BRI)	12/03/1999	Merten Ck, WA	NS	AF482570	NS
842	*Oligocista*	*U. graminifolia* Vahl	Jobson UQ106 (BRI)	26/09/1999	India	NS	AF482573	NS
849	*Oligocista*	*U. meyeri* Pilger	Rivadavia 1014 (SPF)	2/05/1999	Goias, Brazil	NS	AF482582	NS
851	*Oligocista*	*U. nana* A.St.Hil. & Girard	Rivadavia 883 (SPF)	2/04/1999	Minas Gerais, Brazil	NS	AF482585	NS
855	*Oligocista*	*U. prehensilis* E.Meyer	Jobson UQ56A (BRI)	26/09/1999	Zambia	NS	AF482592	NS
881	*Oligocista*	*U. uliginosa* Vahl	Jobson 2673 (NSW)	16/04/2015	Theda Station, WA	OR142168	OR141393	OR141474
896	*Oligocista*	*U. odorata* Pellegrin	Jobson 2705 (NSW)	19/04/2015	Humpty Doo, NT	NS	OR141397	OR141478
924	*Oligocista*	*U. uliginosa* Vahl	Jobson 1894 (NSW)	5/07/2013	Cardwell, Qld	OR142171	OR141403	OR141482
925	*Oligocista*	*U. uliginosa* Vahl	Jobson 1913 (NSW)	5/07/2013	Starke National Park, Qld	OR142172	OR141404	OR141483
926	*Oligocista*	*U. uliginosa* Vahl	Jobson 3141 (NSW)	13/04/2016	Morgans Landing, Qld	NS	OR141405	OR141484
927	*Oligocista*	*U. uliginosa* Vahl	Jobson 3161 (NSW)	14/04/2016	Cape Flattery, Qld	OR142173	OR141406	OR141485

CODE	Section	Taxon	Collector	Coll. Date	Location	ITS	*RPS16*	*TRNDT*
928	*Oligocista*	*U. uliginosa* Vahl	Jobson 2021 (NSW)	10/07/2013	Blencho Falls, Qld	OR142174	OR141407	OR141486
930	*Oligocista*	*U. circumvoluta* P.Taylor	Jobson 2797 (NSW)	16/07/2015	Laura, Qld	NS	OR141408	NS
931	*Oligocista*	*U. circumvoluta* P.Taylor	Jobson 2837 (NSW)	18/07/2015	Jungle Creek, Qld	OR142175	OR141409	OR141487
935	*Oligocista*	*U. uliginosa* Vahl	Jobson 1779 (NSW)	20/04/2013	Portland Road, Qld	OR142176	OR141410	OR141488
936	*Oligocista*	*U. uliginosa* Vahl	Jobson 2856 (NSW)	18/07/2015	Jungle Creek, NT	OR142177	OR141411	OR141489
937	*Oligocista*	*U. uliginosa* Vahl	Jobson 3219 (NSW)	22/04/2016	Darkes Forest, NSW	OR142178	OR141412	OR141490
980	*Oligocista*	*U. uliginosa* Vahl	Jobson 3262 (NSW)	2/10/2016	Mimosa Creek, Qld	OR142179	OR141413	OR141491
1061	*Oligocista*	*U. foveolata* Edgew.	Jobson 3566 (NSW)	28/04/2019	Mitchell Plateau, WA	OR142133	NS	OR141417
1126	*Oligocista*	*U. irwinica* R.W.Jobson & Baleeiro	Jobson 4153 (NSW)	24/06/2022	Steve Irwin WR, Qld	OR142145	OR141332	OR141433
1127	*Oligocista*	*U. uliginosa* Vahl	Jobson 4156 (NSW)	25/06/2022	Punsand Bay, Qld	OR142146	OR141333	OR141434
1129	*Oligocista*	*U. uliginosa* Vahl	Jobson 4196 (NSW)	26/06/2022	Batavia Downs, Qld	OR142147	OR141334	OR141435
1130	*Oligocista*	*U. uliginosa* Vahl	Jobson 4147 (NSW)	24/06/2022	Nimrod Creek, Qld	OR142148	OR141335	OR141436
1131	*Oligocista*	*U. uliginosa* Vahl	Handsen s105 (BRI)	4/06/2017	NE of Aurukun, Qld	OR142149	OR141336	OR141437
1133	*Oligocista*	*U. uliginosa* Vahl	Forster 36596 (BRI)	1/05/2010	Jack River, Qld	NS	OR141337	OR141438
1134	*Oligocista*	*U. uliginosa* Vahl	Searle 106 (BRI)	9/05/2013	Twitheran Creek, Qld	OR142150	OR141338	OR141439
1135	*Oligocista*	*U. uliginosa* Vahl	Mitchell 269 (BRI)	1/03/2009	Steve Irwin WR, Qld	NS	OR141339	OR141440
1136	*Oligocista*	*U. irwinica* R.W.Jobson & Baleeiro	Mitchell 430 (BRI)	3/03/2009	Steve Irwin WR, Qld	NS	OR141340	OR141441
1137	*Oligocista*	*U. irwinica* R.W.Jobson & Baleeiro	Mitchell 227 (BRI)	19/07/2010	Steve Irwin WR, Qld	OR142151	OR141341	OR141442
1138	*Oligocista*	*U. irwinica* R.W.Jobson & Baleeiro	McDonald 11560 (BRI)	13/06/2023	Steve Irwin WR, Qld	OR142152	OR141342	OR141443
1139	*Oligocista*	*U. albocaerulea* Dalz.	Chaudhary DUH14462	13/06/2011	India	MK617624	MK531202	NS
1140	*Oligocista*	*U. babui* S.R.Yadav et al.	Chaudhary DUH14459	23/02/2019	India	MK617628	MK560772	NS
1141	*Oligocista*	*U. bifida* L.	Chaudhary DUH1465	23/02/2019	India	MK617620	MK560767	NS
1142	*Oligocista*	*U. graminifolia* Vahl	Chaudhary DUH14457	23/02/2019	India	NS	MK560774	NS
1144	*Oligocista*	*U. janarthanamii* S.R.Yadav et al.	Chaudhary sn (DUH)	23/02/2019	India	NS	MK560765	NS
1145	*Oligocista*	*U. naikii* S.R.Yadav et al.	Chaudhary DUH14456	23/02/2019	India	MK617621	MK560766	NS
1146	*Oligocista*	*U. polygaloides* Edgew.	Tandon sn (DUH)	23/02/2019	India	NS	MK560768	NS
1147	*Oligocista*	*U. praeterita* P.Taylor	Chaudhary DUH14464	23/02/2019	India	MK617626	MK560775	NS
1148	*Oligocista*	*U. purpurascens* Graham	Tandon sn (DUH)	23/02/2019	India	NS	MK579569	NS
1149	*Oligocista*	*U. reticulata* Sm.	Chaudhary DUH14453	23/02/2019	India	MK617622	MK531203	NS
1155	*Oligocista*	*U. uliginosa* Vahl	Muramatsu P2179	10/08/2012	Japan	LC682656	NS	NS
678	*Stomoisia*	*U. juncea* Vahl	Baleeiro 259 (NSW)	15/07/2009	Gois, Brazil	NS	OR141372	NS
833	*Stomoisia*	*U. coruta* Michx	Fryxell 4946 (NY)	1/04/1986	Texas, USA	NS	AF482564	NS
844	*Stomoisia*	*U. juncea* Vahl	Jobson UQ136A (BRI)	12/03/1999	Georgia, USA	NS	AF482576	NS
830	*Calpidisca**	*U. bisquamata* Schrank	Jobson UQ51	12/03/1998	South Africa	NS	AF482562	NS
687	*Nelipus**	*U. limosa* R.Br.	Jobson 2037 (NSW)	13/07/2013	Burrum Point, Qld	NS	OR141375	NS
1125	*Nigrecentes**	*U. warburgii* Goebel	Jobson 4055	14/04/2022	China	NS	OR141331	OR141432
613	*Nigrescentes**	*U. caerulea* L.	Jobson 1275	7/06/2011	Musgrave, Qld	OR142153	OR141345	OR141446
104	*Pleiochasia**	*U. ameliae* R.W.Jobson	Jobson 2188 (NSW)	16/04/2014	E of Boulia, Qld	MK259674	KY243405	KY243695

Within sect. *Oligocista*, three well supported clades were found (Fig. 1). Clade A consisted of neotropical taxa and *U. nana* (sect. *Benjaminia*) and formed a sister clade to the African/Asian/Australasian (clades B and C, Fig. 1). In clade B the African species *U. prehensilis* E.Meyer is sister to four Australian species (Fig. 1) that all possess a yellow corolla. Clade C consisted mostly of species with corolla colour in varied shades of violet or blue (Fig. 1) and these are distributed in India, SE Asia and Australasia, with a single widespread species *U. foveolata* Edgew. extending from Australia into Africa. Within clade C, the *U. uliginosa* clade consisted of two subclades RWJ-3219 (lacking strong support) and RWJ-4169 (well supported), corresponding to two morphological forms (Fig. 1). Both of these forms are distributed across Cape York, the former distributed across northern Australia and extending into Asia while the latter broadly distributed across along the east coast of Australian and likewise extending into Asia (RWJ pers. observation). Our accessions of *U. uliginosa* are from across the entire Australian distribution with inclusion of a representative from New Caledonia (*Hequet s.n.*) and Japan (*Muramatsu P2179*) respectively (Table 1; Fig. 1). Sister to *U. uliginosa* is a strongly supported clade containing four accessions of *U.* sp. Steve Irwin Reserve (R.W.Jobson 4153) with both these clades together strongly supported and sister to the morphologically similar Indian species *U. praeterita* (Fig. 1).

The phylogeny resolved *U. uliginosa*, *U.* sp. Steve Irwin Reserve (R.W.Jobson 4153) and *U. praeterita* in an unsupported clade and revealed genetic divergence between all three entities that mirrors key morphological differences (refer to key). Taxonomic description and illustrations of this close relative of *U. uliginosa* is here described as *U. irwinica* R.W.Jobson & Baleeiro sp. nov. The morphological differences between *U. irwinica*, *U. uliginosa*, and *U. praeterita* are discussed, and an identification key is provided along with the distribution and habitat preference of the new species.

Taxonomy

Utricularia irwinica R.W.Jobson & Baleeiro, *sp. nov.*

Diagnosis: Similar to *U. praeterita* in having upper corolla lip longer than the upper calyx lobe and seeds ovoid but differs in having mostly cream-white *vs* deep blue lower corolla lip in *U. praeterita*, and spur upper half cream-white, apical half faint purple *vs* entirely bluish purple in *U. praeterita*.

Type: AUSTRALIA: QUEENSLAND: Cape York Peninsula: Steve Irwin Wildlife Reserve, upper tributary of Bertiehaugh Creek [precise location withheld], *R.W. Jobson 4153 & PC. Baleeiro*, 24 June 2022, holo [prepared as two parts]: NSW1125309 (sheet), NSW963027 (spirit); iso: BRI (spirit).

Small, probably perennial, terrestrial or subaquatic herb. *Rhizoids* few, capillary, branched up to 20 mm long, 0.3 mm thick, from base of peduncle. *Stolons* numerous, capillary, 0.10–0.22 mm thick, branched, up to 50 mm long, internode length 5–10 mm long. *Leaves* numerous, one from stolon nodes, petiolate; lamina linear to lanceolate, 10–30 mm long, 0.3–5.0 mm wide, 3–7 nerved, apex rounded or acute, total length 35–55 mm. *Traps* few on rhizoids, one at internode of stolon, occasionally on leaves, globose, shortly stalked, mouth basal with two simple, subulate dorsal appendages, surface of stalk and appendages adorned with short glands. *Inflorescence* erect, solitary, 55–220 mm long; peduncle filiform, glabrous, solid, 0.2–0.3 mm thick. *Scales* few, basifixed, ovate apex subacute, 0.5–1.1 mm long, 0.3–0.5 mm wide. *Bracts* basifixed, ovate with apex acute, slightly swollen at base with scattered sessile glands, 1.0–1.3 mm long, 0.5–0.7 mm wide. *Bracteoles* linear, 0.6–0.7 mm long, 0.2–0.3 mm wide. *Flowers* (1–)2 or 3, raceme elongated; pedicels suberect, apically curved, slightly dorsiventrally flattened, 1.5–2.0 mm long. *Calyx* lobes unequal; upper lobe 2.8–3.0 mm long, 2.2–2.5 mm wide, ovate, slightly convex, apex acute; lower lobe 2.8–3.0 mm long, 1.8–2.2 mm wide, ovate, with apex bidentate; upper lobe margin minutely papillose at maturity. *Corolla* cream-white, 5.5–6.5 mm long with apical half of spur faint purple; upper lip erect or decurved, constricted near middle with superior part ovate, apex rounded, longer than the upper calyx lobe, inferior part oblong, galeate; lower lip limb circular, galeate, with prominent swelling near middle; palate with raised, distally pubescent rim; spur slightly conical at base, diverging at *c.* 90°, curved forward, longer than the lower lip, apex acute. *Staminal filaments* slightly curved, *c.* 0.1 mm long; anther thecae distinct. *Ovary* ovoid, *c.* 1 mm long; style *c.* 0.5 mm long; stigma with lower lip ovate, upper lip shorter, truncate. *Capsule* ovoid, *c.* 2.5 mm long; walls thin, membranous, dehiscing by a single, ventral, longitudinal, unthickened slit. *Seeds* ovoid 0.25–0.30 mm long, testa cells elongated with anticlinal walls raised. *Pollen* 3- or 4-colporate, 25 × 25 μm (*R.W. Jobson 4153 & P. Baleeiro*). Figs 2, 3, 4a, b, 5a, b.

Additional specimens examined. Queensland: Cook District: N of Weipa Airport, *A. Mitchell 14-430 & B. Massey*, 3 Mar 2009 (BRI); NE of Weipa, *A. Mitchell 227 & E. Miller*, 19 Jul 2010 (BRI); Steve Irwin Wildlife Reserve, N of Coolibah Ranger Station, *K.R. McDonald KRM11560 & B.J. Lyon*, 13 Jul 2011 (BRI).

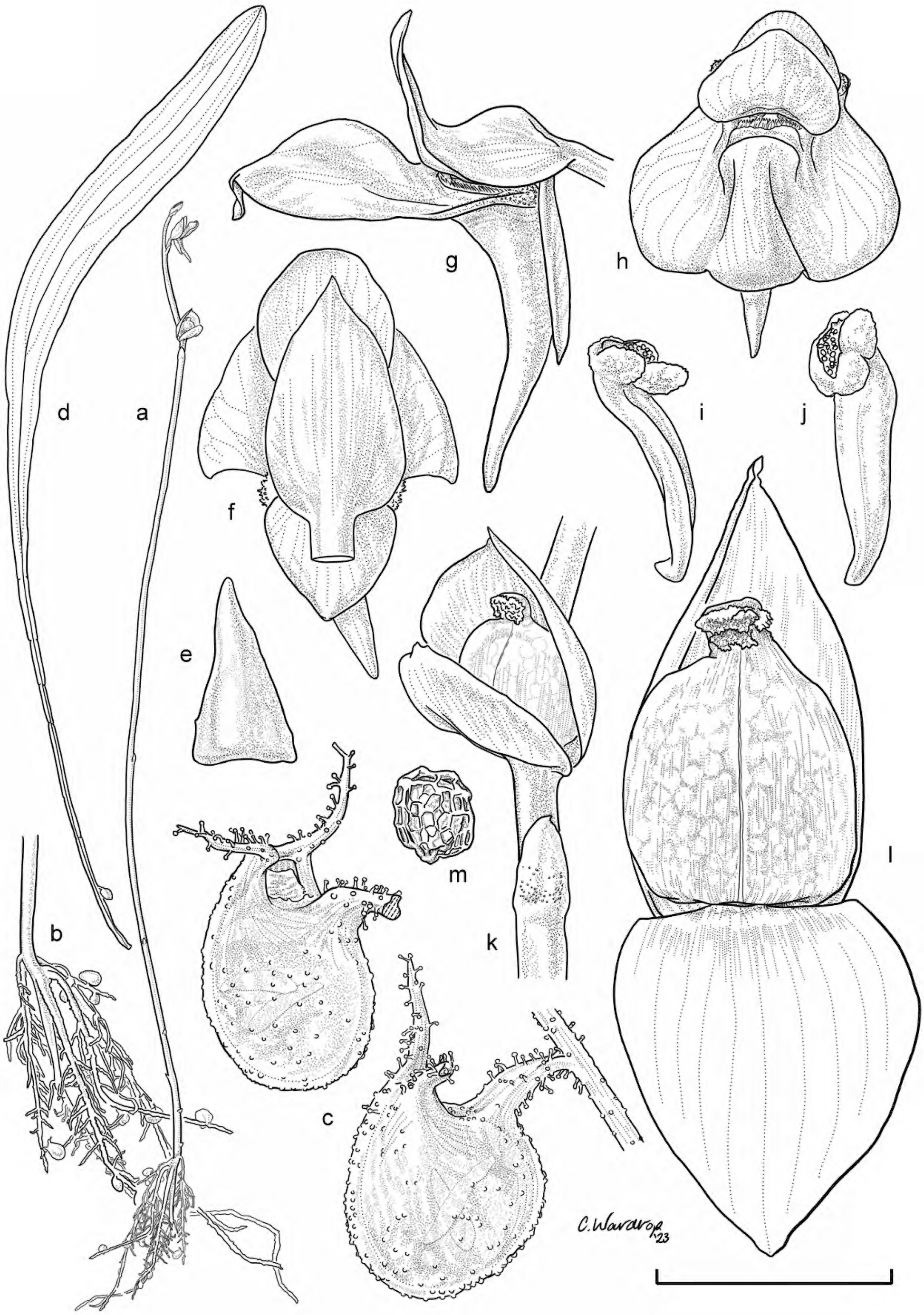

Fig. 2. *Utricularia irwinica*. a, habit; b, stolons with attached rhizoids from peduncle base in situ; c, bladder-trap lateral and ¾ view; d, leaf adaxial surface; e, bract; f, flower dorsal view; g, flower lateral view; h, flower frontal view; i, stamen lateral view; j, stamen frontal view; k, mature fruit capsule in situ; l, mature fruit capsule frontal view; m, seed. Scale bar: a = 32 mm; b & d = 10 mm; c, e, i & j = 1.25 mm; f–h & k = 3.2 mm; l = 2 mm; m = 0.8 mm. Material used: *Jobson 4153 & Baleeiro* (NSW963027 - spirit). Illustration by C. Wardrop.

Distribution, Ecology & Phenology: Known only from four small spring-fed creek sites between the Wenlock and Ducie River catchments of western Cape York Peninsula (Fig. 6). All sites are within the Steve Irwin Wildlife Reserve. Grows in shallow water (1–5 cm depth) in a thin layer of mud over hard lateritic substrate (Fig. 3). Flowers observed March to July.

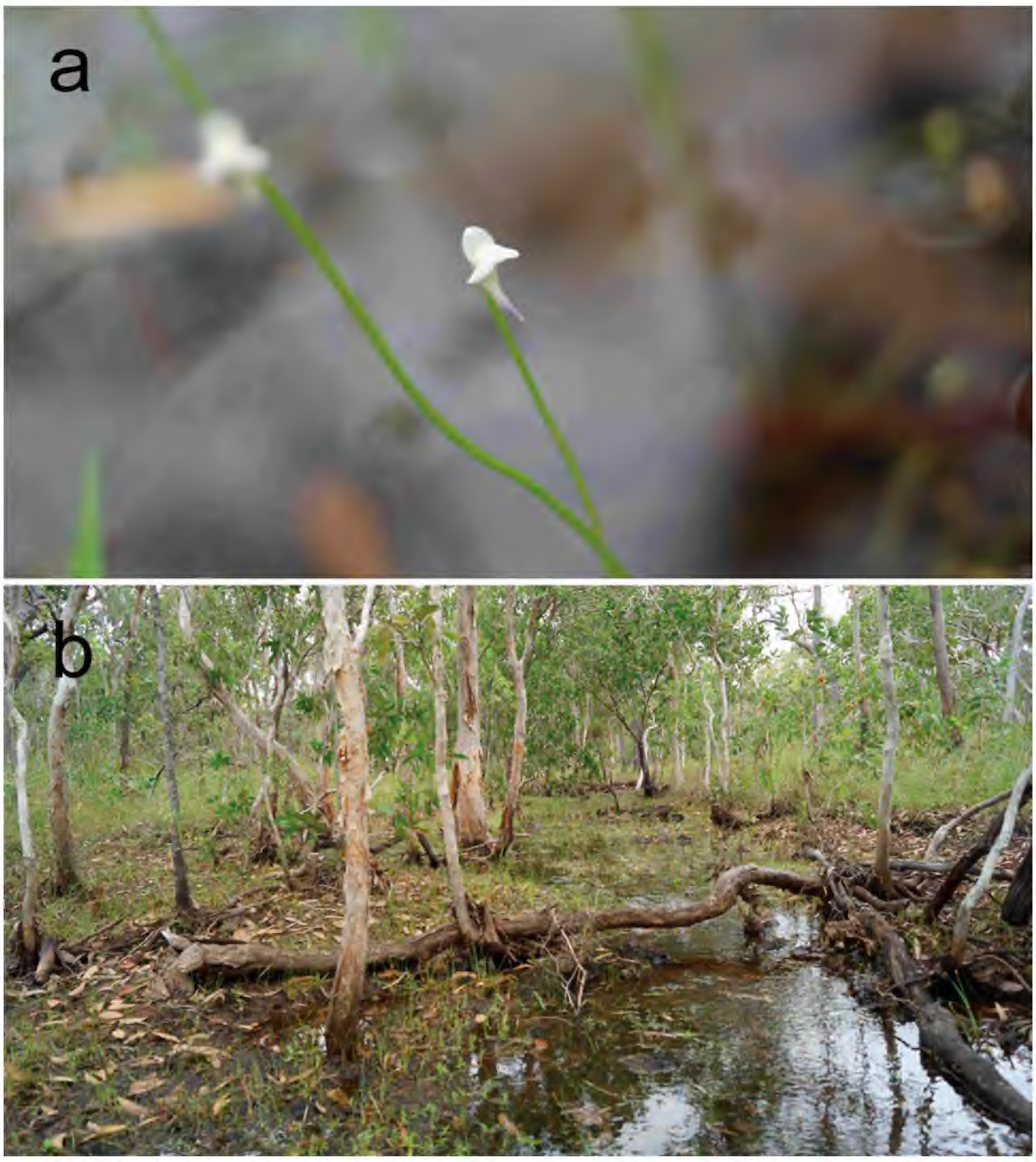

Fig. 3. Typical erect habit (a) and habitat (b) of *Utricularia irwinica*. Images = R. Jobson (*R.W. Jobson 4153 & P.C Baleeiro*)

Conservation status: This rarely collected species is known from four sites within the Steve Irwin Wildlife Reserve (Fig. 6). Although the reserve is conservation managed, wild pig damage was observed at the type location during the time of specimen collection. Perhaps the saving grace for these plants is the hard laterite substrate that seems to prevent pigs rooting through their microhabitat – unfortunately, the surrounding soft soil habitat was damaged. Despite broad surveys in the area, and the known threats, the known distribution is limited, but an assessment under IUCN equivalent Criteria for the Queensland Nature Conservation Act and the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) has not been performed.

Etymology: The specific epithet *irwinica* refers to the Steve Irwin Wildlife Reserve. Formerly known as Bertiehaugh Station, the reserve has been set aside as a tribute to the conservation work of Steve Irwin and is a place for scientific research and discovery.

Notes: We examined an image of the holotype of *U. uliginosa* Vahl, "India orientalis" *Koenig s.n.*, 1804 (holo, C 10013933 - image), along with all available images of type specimens synonymised under *U. uliginosa* (Taylor 1989): *U. cyanea* R.Br., Grose River, NSW, *Brown #2729*, 1804 (holo, BM001041163 - image); *Utricularia brachypoda* Wight, "Peninsula Ind. orientalis", *Wight 2411*, 1836 (iso, E00174037 - image); *Utricularia griffithii* Wight "peninsula Indiae orientalis", *Wight s.n.*, 1849 (holo, K 000450576 - image). From this examination we found that none of these specimens exhibited the characters that define *U. irwinica*, namely corolla upper lip and corolla spur exceeding the length of the upper calyx lobe and corolla lower lip, respectively (Fig. 4).

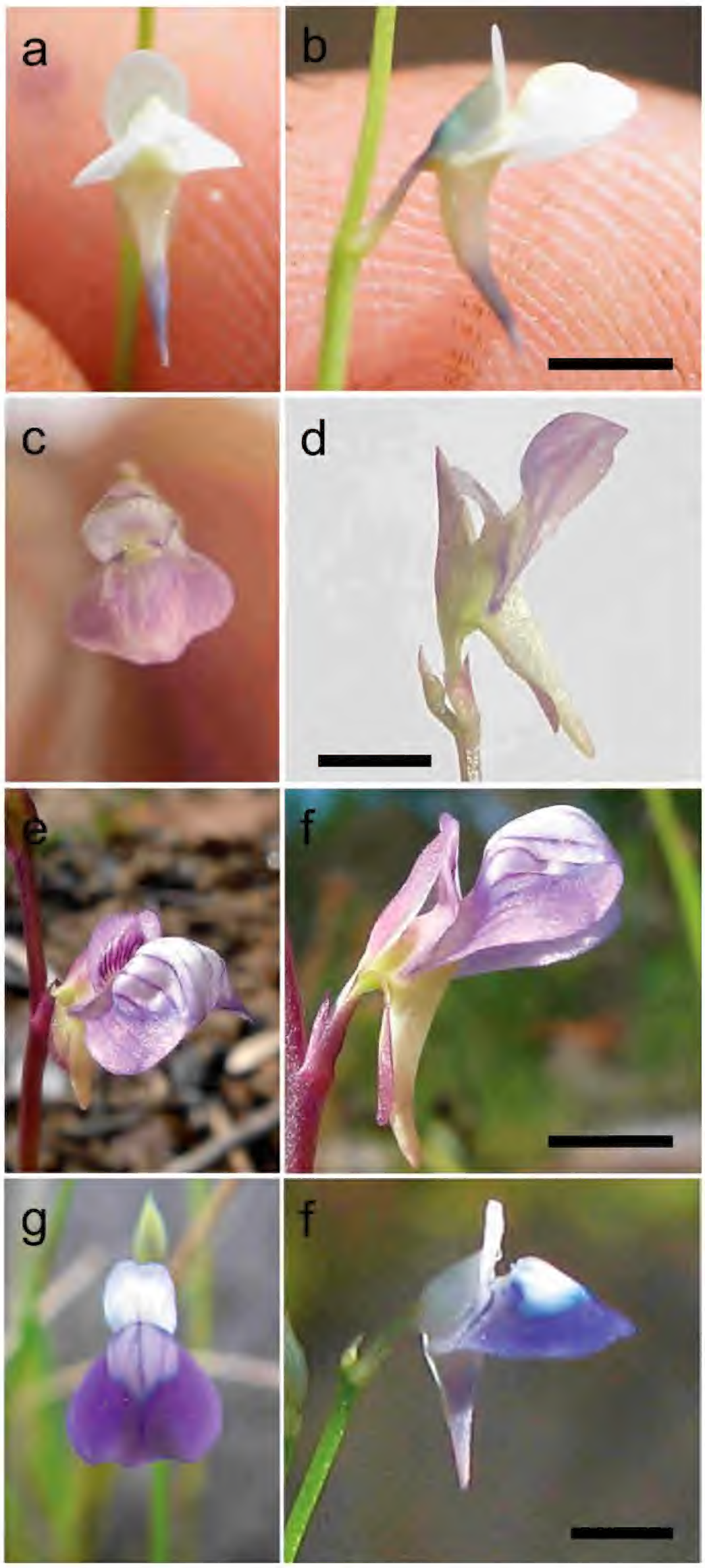

Fig. 4. *Utricularia irwinica* (a, b), *U. uliginosa* [RWJ-4169] (c, d), *U. uliginosa* [RWJ-3219] (e, f), *U. praeterita* (g, h); a, c, e, g corolla frontal view; b, d, f, h corolla lateral view. Scale bars: a–h = 3 mm (e–h are estimated). Images: a & b, by R.W. Jobson; c & d by A.P. Jobson; e & f and g & h with permission from John Tann and N. Sasidharan, respectively.

For other properly applied taxa listed by Taylor (1989) and Kew's POWO (2023) listed as synonyms of *U. uliginosa* we examined their protologues to determine whether they fit any of the major morphological characters of *U. irwinica*: the length of the spur relative to the lower calyx lip and the colour of the corolla (violet/blue/purple *vs* white). The synonyms described to have violet or purple flowers included *U. affinis* Wight (India: Hooker's *J. Bot. Kew Gard. Misc.* 1: 373, 1849), *U. decipiens* Dalzell (India; *Hooker's J. Bot. Kew Gard. Misc.* 3: 279, 1851), *U. intricata* Griff. ex Oliv. (Malaysia; *J. Proc. Linn. Soc., Bot.* 3: 179, 1859), and *U. lilacina* Griff. (Burma; *Not. Pl. Asiat.* 6(4): 168, 1854). Those that did not mention corolla colour but did describe a spur shorter or equal to the length of the lower calyx lip include *U. elachista* Goebel (India; *Ann. Jard. Bot. Buitenzorg* 9: 76, 1891) and *U. nayarii* Janarth. & A.N.Henry (India; Janarthanam & Henry 1992)).

Synonyms of which no type specimen or protologue could be located include *U. macrophylla* Masam. & Syozi (Taiwan), *U. uliginosa* f. *albida* (Makino) Komiya & C.Shibata (Japan; *Bull. Nippon Dental Univ*. 9: 179, 1980), *and U. yakusimensis* Masam. (Japan; *Mem. Fac. Sci. Taihoku Imp. Univ*. 11: 409, 1934). Given the distance between Japan and the type location it is unlikely these three synonyms represent *U. irwinica*.

The description for *U. cyanea* in Bentham (1868) includes designation of a white variety *U. cyanea* var. *alba* Benth., collected by *Dallachy s.n*. at Rockingham Bay, Qld, between 1863 and 1871. To check the identity of *Dallachy s.n*., we obtained an image of the three sheets representing type specimens (MEL 0089867, MEL 0089868, MEL 0089869) and here designate MEL 0089869 as lectotype of *U. cyanea* var. *alba* Benth. We determined that Bentham's white varietal form *U. cyanea* is not similar to *U. irwinica* because it corresponds with the morphology of *U. uliginosa*: the upper corolla lip is shorter than the upper calyx lip and the spur is only marginally longer than the lower calyx lip (Fig. 1; 4c, d; 5d–f). We also checked the short description of *U. uliginosa* var. *alba* F.L.Erickson, in Erickson (1968). Erickson (1968) noted that white forms of *U. uliginosa* are distributed from Bundaberg (Qld) to Botany Bay (NSW) and possess a slightly smaller calyx than those of the typical form. However, given our observations across these populations and that there is no mention of *U. irwinica* characteristics other than corolla colour across this distribution, we consider *U. uliginosa* var. *alba* a synonym of *U. uliginosa*.

Our phylogeny shows *U. praeterita* is sister to *U. uliginosa* and *U. irwinica* (Fig. 1) with all three species sharing a uniformly membranous fruit capsule (see above and Taylor 1989). In Australia, there are two morphological forms of *U. uliginosa* defined by two subclades (RWJ-3219 and RWJ-4169) in the phylogeny (Fig. 1). They are characterised by differing corolla coloration and patterning: usually pink *vs* blue or violet and, presence of four darker vertical stripes at the base of the upper lip limb *vs* up to 12, respectively.

A character for distinguishing *U. uliginosa* (both forms) is the minutely denticulate margin of the upper calyx lobe when mature, while in *U. praeterita* and *U. irwinica* the upper calyx lobe margin is instead minutely papillose (Fig. 5b, e, h; refer to fig. 87 in Taylor 1989 for *U. praeterita* illustration and description).

Taylor (1989) describes seed coat and shape as the most reliable character to differentiate *U. praeterita* and *U. uliginosa*. The seed of *U. irwinica* are ovoid with elongated testa cells and most similar to *U. praeterita,* although those of the latter are larger (0.2–0.3 *vs c*. 0.35 mm long in *U. irwinica*) (Fig. 5c). In comparison, in both forms of *U. uliginosa*, the seeds are globose with isodiametric testa cells (Fig. 5f, i).

In comparison to the short inflorescences of *U. praeterita* (2–15 cm tall), *U. irwinica* and *U. uliginosa* are taller, reaching 22 cm and 30(–40) cm tall, respectively (Taylor 1989). Although none of these species have previously been recorded as having a twining peduncle, a tall twining form of *U. uliginosa* (*c*. 40 cm tall) was recently collected at Cape Flattery on Cape York Peninsula (*R.W. Jobson 3141*); the representative specimen with this form nests within the RWJ-3219 clade of *U. uliginosa* (Fig. 1).

The upper corolla lip of *U. praeterita* and *U. irwinica* exceeds the length of the upper calyx lobe while that of *U. uliginosa* is always approximately the same length or shorter (Fig. 4; Taylor 1989; RWJ pers. observation). The corolla colour of each of the three species differs but is most similar between *U. praeterita* and both forms of *U. uliginosa* (Fig. 4). These two species share dark violet vertical stripes on upper and lower lip limbs with the number on the upper lip varying from four to 12 across the distribution of the latter species (Fig. 4; RWJ pers. observation).

Although Taylor (1989) mentions Australian populations with a white corolla in his *U. uliginosa* description, we have noticed that the typical corolla patterning in two such populations is faintly observable upon close examination (RWJ, pers. observation). Representatives of these white forms are included in the phylogeny (e.g., *Jobson 4147, 4196*; Fig. 1; Table 1) and are recovered within the *U. uliginosa* clade. In contrast, the corolla of *U. irwinica* can easily be distinguished from these forms because its corolla is a rich cream-white becoming purple towards the apex of the spur (Fig. 4a, b; RWJ, pers. observation). Spur length and shape differ between these two species. Spurs of *U. uliginosa* are usually shorter than the upper corolla lip and less curved than in *U. irwinica*, which has a spur that is longer than the upper lip and conspicuously curved forward (Fig. 4c–f; 5 a, d, g).

Habitat similarities of *U. praeterita* and *U. irwinica* include shallow soil over a laterite (or other rocks in the former species) substrate in seasonal or spring-fed creeks (Fig. 3b). However, *U. uliginosa* occupies a much broader array of habitats in sandy silt of seepages, such as in creeks and swamps (Taylor 1989) as demonstrated by recent collections of *U. uliginosa* made in such habitats within the Steve Irwin Wildlife Reserve (e.g., *Jobson 4147, Mitchell 269*; Fig. 6).

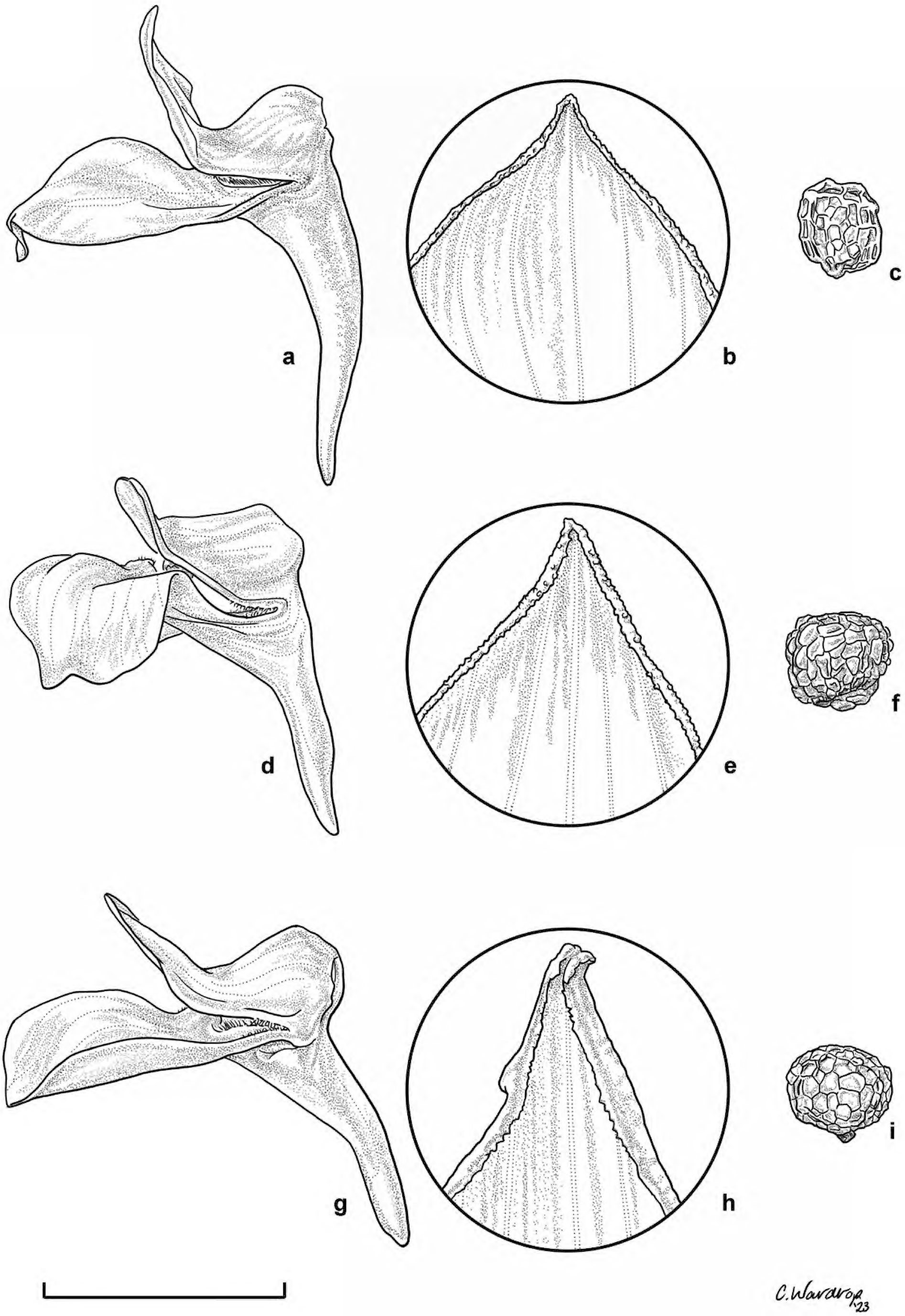

Fig. 5. Comparison of *Utricularia irwinica* (a–c), *U. uliginosa* (d–i); a, d & g, corolla shape lateral view; b, e & h adaxial surface of upper calyx showing incurved margin; c, f & i seed shape. Scale bar: a, d & g = 3.2 mm; b, e & h = 1.25 mm; c, f & i = 0.8 mm. Material used: a–c = *Jobson 4153 & Baleeiro* (NSW963027 - spirit); d–f = *Jobson 4196 & Baleeiro* (NSW963040 - spirit); g–i = *Jobson 3219 & Baleeiro* (NSW934787 - spirit).

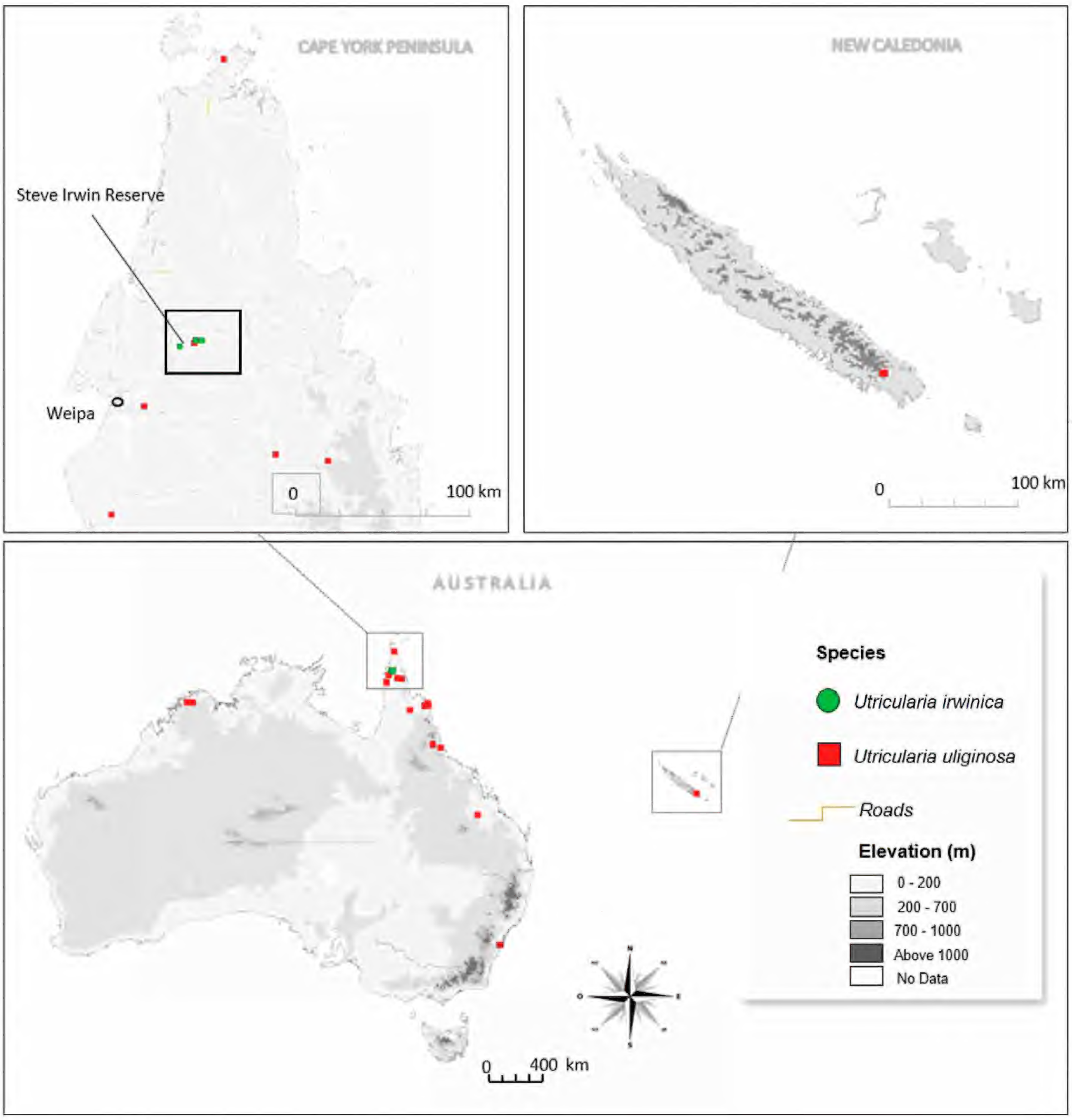

Fig. 6. Distribution map for Australia and New Caledonia showing accessions used in the molecular phylogeny of sect. *Oligocista*. *U. irwinica* (green circle), *U. uliginosa* (red square). For accession details refer to Table 1.

Key to Australian and relevant foreign species of section *Oligocista*

1a. Corolla with shades of violet, cream-white or white **2**

1b. Corolla yellow **5**

2a. Corolla 3–4 mm long, bladder-trap dorsal appendages branched ..... ***U. foveolata*** **(WA, NT, Qld)**

2b. Corolla 5–8 mm long; bladder-trap dorsal appendages simple **3**

3a. Corolla upper lip limb length shorter or equal to upper calyx lip ..... ***U. uliginosa*** **(WA, NT, Qld, NSW)**

3b. Corolla upper lip limb longer than the upper calyx lip **4**

4a. Corolla cream-white, spur violet towards the apex ..... ***U. irwinica*** **(Qld)**

4a. Corolla violet, spur light violet, darker towards the apex ..... ***U. praeterita*** **(India)**

5a. Peduncle weakly erect, always twining **6**

5b. Peduncle erect, not twining **7**

6a. Corolla ±5 mm long..... ***U. circumvoluta*** **(WA, NT, Qld)**

6b. Corolla 10–15 mm long..... ***U. involvens*** **(NT)**

7a. Corolla 6–10 mm long; inflorescence 3–20 cm high..... ***U. bifida*** **(WA, NT, Qld)**

7b. Corolla 10–15 mm long; inflorescence 25–55 cm high ..... ***U. odorata*** **(NT)**

Revised sectional taxonomy

We recommend the following changes to sectional taxonomy based on the results shown in Fig. 1 and morphology. *Utricularia* L. sect. *Enskide* should be expanded to include the single species in *Utricularia* L. sect. *Minutae*. The three accessions from across the distribution (Table 1) form a clade nested within a strongly supported clade of all recognised members of sect. *Enskide* (Fig. 1). The molecular results are supported by morphology with similarity of bladder-traps and pollen structure (Taylor 1989; Cowie et al. 2008). *Utricularia* L. sect. *Oligocista* should be expanded to include the species in *Utricularia* L. sect. *Benjaminia*. *Utricularia nana* was nested within sect. *Oligocista* (Fig. 1). The molecular results are supported by morphology as outlined in Taylor (1989).

Utricularia L. sect. ***Enskide*** (Raf.) P.Taylor, *Kew Bull*. 41: 9 (1986)

Utricularia L. sect. *Minutae* Lowrie, Cowie & Conran, *Telopea* 12: 31–46 (2008), *syn. nov. Type: U. simmonsii* Lowrie, Cowie & Conran.

Utricularia L. sect. ***Oligocista*** A.DC. in DC., *Prodr*. 8: 12 (1844) *sensu* P. Taylor, *Kew Bull*. 41: 9 (1986)

Utricularia L. sect. *Benjaminia* P.Taylor, *Kew Bull*. 41: 8 (1986), *syn. nov*.

Type: *U. nana* A.St.-Hil. & Girard.

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Caesia walalbai A.T.Webb, Birch & R.L.Barrett (Asphodelaceae, Hemerocallidoideae), a new species from south-east Queensland

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Abstract

Caesia walalbai A.T.Webb, Birch & R.L.Barrett (Asphodelaceae, Hemerocallidoideae) is described as a new species endemic to south-east Queensland, Australia. It is distinguished from other white-flowered, eastern Australian *Caesia* species by long, often recurved pedicels and entirely yellow staminal filaments. *Caesia walalbai* is notable for having 23 observations on the citizen science platform iNaturalist, all made in the last three years, while a similar number of herbarium specimens have been collected, the first in 1959. The species was also collected on the Carnarvon Station Reserve BushBlitz in 2014. A new description of *Caesia parviflora* R.Br. *s. str.* is provided based on specimens collected in the Sydney region of New South Wales, the type location for the species.

Introduction

Caesia R.Br. (Asphodelaceae subfam. Hemerocallidoideae) contains 14 species and eight additional entities that are recognised by phrase names in Western Australia (Western Australian Herbarium 1998–) and the Northern Territory (Northern Territory Herbarium 2023). The genus is predominantly Australian (10 species), with *C. setifera* Baker extending to Papua New Guinea, and four species in South Africa and Madagascar (Henderson 1987; Boatwright & Manning 2010). *Caesia* occupies a diverse array of habitats across much of Australia. In eastern Australia, species are most often found in the grassy understorey of eucalypt woodlands and in heathlands (Clifford *et al.* 1992; McCune & Hardin 1993; Conran & Walsh 1994).

Australian *Caesia* taxonomy has remained largely unaltered since the *Flora of Australia* treatment (Henderson 1987). Exceptions include two additions to the genus, *C. viscida* Keighery and *C. arcuata* T.Macfarlane, Conran & C.J.French (Keighery 1990; Macfarlane *et. al.* 2020), and nomenclatural changes at familial rank [Xanthorrhoeaceae in APG III (The Angiosperm Phylogeny Group 2009), Asphodelaceae in APG IV (Klopper *et al.* 2013; Chase *et al.* 2016)]. Phylogenetic studies place *Caesia* sister to an *Arnocrinum* Endl. & Lehm., *Hensmania* W.Fitzg., *Hodgsoniola* F.Muell., plus *Johnsonia* R.Br. clade, which is successively sister to *Corynotheca* (Webb, unpublished MSc thesis; Webb *et. al.*, in prep., Wurdack & Dorr, 2009; Chen *et al.* 2013). A recent revision of *Corynotheca* F.Muell. ex Benth. (Barrett *et al.* 2021) has highlighted the requirement for similar work within *Caesia* and as such, the genus is the subject of phylogenetic study (Webb *et al.*, in prep.).

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Caesia diversity in eastern Australia currently comprises five species. The most widespread and prevalent of these is *Caesia parviflora* R.Br., a species complex found from Brisbane, Queensland, in proximity to the coastline through to south-eastern South Australia (Henderson 1987). It has previously been reported from Cape York Peninsula (Henderson 1987), but these collections are now referred to *C. setifera s. lat*. *Caesia parviflora* is morphologically variable and currently contains three infraspecific taxa: *C. parviflora* R.Br. var. *parviflora*, *C. parviflora* var. *minor* R.J.F.Hend. and *C. parviflora* var. *vittata* (R.Br.) R.J.F.Hend. Morphological characters that are cited for distinguishing *C. parviflora* varieties are limited to flower colour, inflorescence orientation and size, and root morphology.

Eastern Australian *Caesia* taxa, *C. alpina* Hook.f., *C. parviflora* and *C. setifera*, are easily overlooked in the vegetation understory unless flowering, as their leaves are typically sparse and narrow. Many of the features required for identification of *Caesia* taxa (e.g. flowers, seeds, roots) are often not collected or do not retain necessary details (e.g. colour) in voucher specimens. As a result, accurate assessment of taxonomic boundaries for eastern *Caesia* species, particularly *C. parviflora*, is challenging and species diversity is likely underestimated. For this reason, we here define and describe *C. parviflora s. str*. based on *C. parviflora* var. *parviflora* specimens (i.e. excluding vars. *minor* and *vittata*) and field observations of plants from the Sydney region to enable critical comparison of other species and varieties. Taxonomic revision of the *Caesia parviflora* complex is ongoing. This study highlights the value to taxonomic research of photographic records on citizen science platforms like iNaturalist (2023) for the documentation of ephemeral organs, especially colour and shape (Mesaglio *et al*. 2023).

Caesia walalbai A.T.Webb, Birch & R.L.Barrett is a new species in *Caesia* which, until recently, had gone largely unnoticed in south-eastern Queensland, where it is endemic. Prior to this publication, this entity has been identified as *C. parviflora* var. *parviflora*, contributing to confusion associated with taxonomic delimitation within the *Caesia parviflora* complex. It is most readily recognised by distant flower cluster spacing, with long, recurved pedicels giving the flowers a pendulous appearance, and entirely yellow staminal filaments. *Caesia walalbai* resembles *C. parviflora* and *C. setifera*, but is readily distinguished from them, as discussed below. *Caesia walalbai* is recognised by morphology (this paper) and preliminary phylogenetic analyses associated with an ongoing broader study of *Caesia* (Webb, unpublished MSc thesis; Webb *et. al*., in prep.).

Methods

Fieldwork was conducted in South Australia, New South Wales, and Victoria to understand and document the morphological and ecological diversity within the *Caesia parviflora* complex. *Caesia* specimens at the State Herbarium of South Australia (AD), Queensland Herbarium (BRI), National Herbarium of Victoria (MEL), University of Melbourne Herbarium (MELU), National Herbarium of New South Wales (NSW) and Tasmanian Herbarium (HO) were examined. Images of *Caesia* plants growing north of Brisbane, in Vernon Conservation Reserve, Hervey Bay, Burrum Coast National Park and Coonarr, north of Hervey Bay, Queensland, by Scott Gavins, Tony Eales and Geoffrey Sinclair in 2021 on iNaturalist (2023), were observed by the first author to be morphologically distinct from *Caesia parviflora*. This prompted the request for a voucher specimen, which was collected by Ted Johansen and lodged at BRI. Further observations on iNaturalist have been made from Freshwater National Park, Maryborough, Springwood Conservation Park, and Tuan Forest. Specimens resembling the new collection were obtained on loan and were studied at The University of Melbourne Herbarium, Victoria. Morphological measurements of 16 individuals of the target taxon were made using a dissecting microscope. These measurements were compared to those of other *Caesia* species, generated during earlier herbarium-based study. Thus, all measurements pertain to dried material. All specimens cited have been examined by the authors unless noted as images seen (denoted by *). Notes on ephemeral and colour-based features are derived from observations and associated images made available on iNaturalist (2023).

Taxonomy

Caesia walalbai A.T.Webb, Birch & R.L.Barrett, *sp. nov.*

Type: Vernon Conservation Reserve, Hervey Bay, Queensland, 6 September 2022, *T. Johansen s.n.* (holotype: BRI AQ1036032).

Rhizomatous, annual *herb* to 75 cm high; *roots* fleshy-fibrous or narrowly tuberous. *Leaves* (10–)20–50 cm long, linear, ascending to recurved, basal, seasonally senescent, green, abaxial and adaxial surfaces discolorous when fresh, apices acute; lamina 1–3 mm wide, slightly biconvex when young, canaliculate, glabrous, margins slightly inrolled and entire or minutely undulate to finely sinuate due to many small projections; sheath papery, reddish, persists as fine bristles following senescence. *Inflorescence* 1-per-plant, 35–75(–85) cm tall, paniculate; axis terete, slender, 1–several-branched; flower clusters distant, not overlapping, (1–)2–4-flowered. Bract subtending

lowest branch linear–lanceolate, (5–)20–50(–100) mm long, > 3× length of upper bracts subtending flower clusters; upper bracts subulate or lanceolate, 1.5–3 mm long, green to brown. *Pedicels* (6–)10–20(–30) mm long, slender, often recurved, red or green. *Flowers* pedicellate, erect to pendulous. *Perianth* segments 6, 4–6 mm long, narrowly elliptic, thin, spreading to recurved, two-toned in colour. Outer whorl white or pale pink to red-brown with subterminal, short, reflexed, apical trichomes, inner whorl white to cream, both whorls with green to brown nerves and obtuse apices, segments twist following anthesis. *Stamens* 6, equal, 2–3 mm long, epitepalous, attached slightly above tepal base; filaments fusiform, yellow with clear apex; anthers *c.* 0.5 mm long, yellow, dorsifixed, versatile. *Ovary* green, ± spheroidal, smooth, 3-locular; ovules 2 per locule; placentation axile; style simple, filiform, of similar length to stamens; stigma minutely capitate. *Capsules* 3–6 mm wide, surface often with irregular, rounded projections, tripartite, loculicidual, 1 or 2 seeds developing per locule, green. *Seeds* 1.3–2 mm wide; testa dull black, granular with sparse, irregular tubercles; aril papery, not sheathing seed. (Figs 1 & 2)

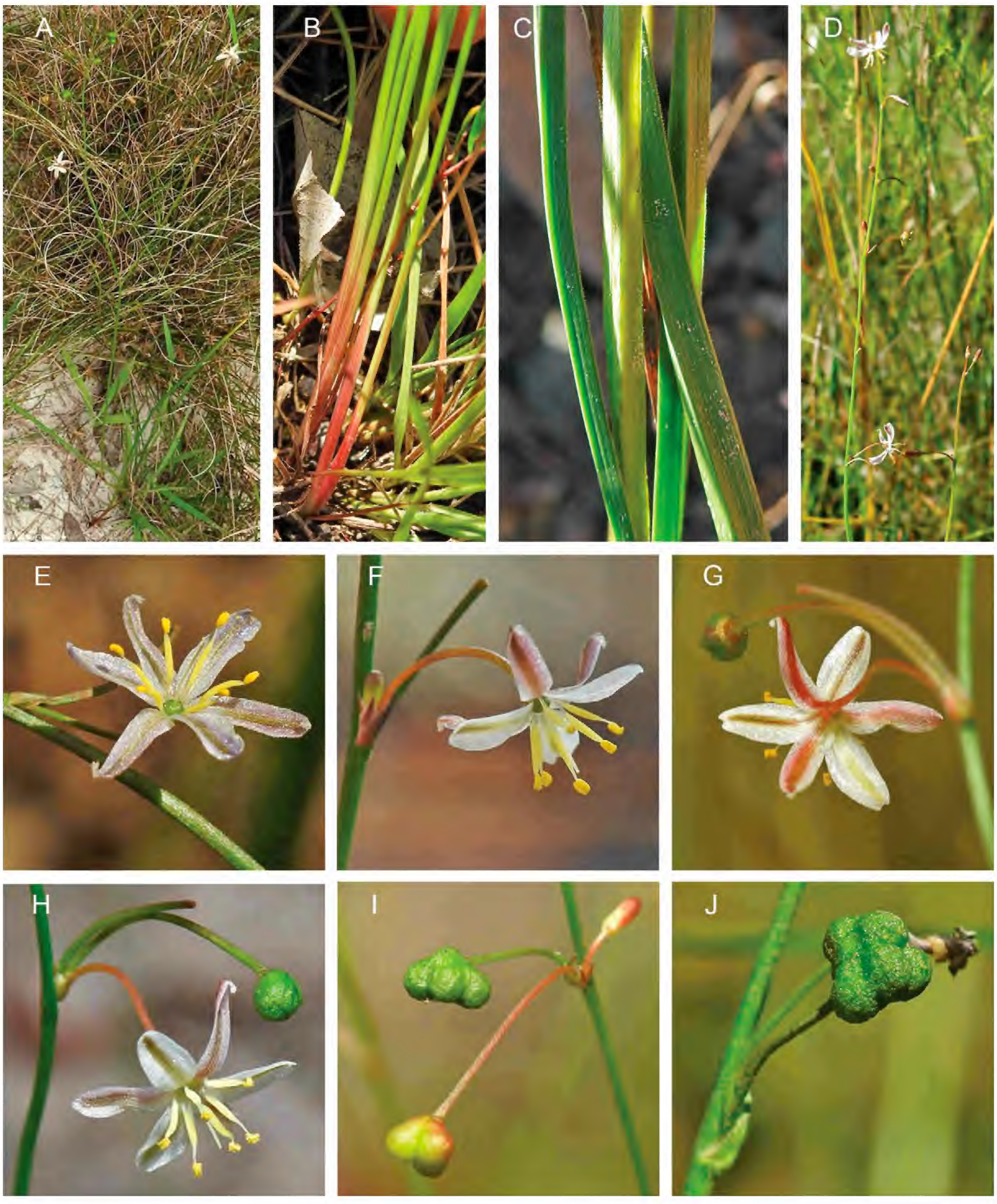

Figure 1. *Caesia walalbai* from Hervey Bay, Maryborough and near Talegalla Weir, Tuan State Forest, Queensland, Australia. A. Habit; B. Leaf sheath; C. Leaf lamina; D. Inflorescence; E–H. Flowers showing pedicels depicting yellow filaments and long, recurved pedicels; I, J. Mature and developing (centre) capsules. Photos by Scott Gavins.

Figure 2. Holotype of *Caesia walalbai* from Vernon Conservation Reserve, Hervey Bay, Queensland (*T. Johansen s.n.*; BRI AQ1036032). Specimen reproduced with permission from Queensland Herbarium & Biodiversity Science, Brisbane, Queensland.

Diagnostic characters: *Caesia walalbai* is the only eastern Australian *Caesia* species with entirely yellow staminal filaments. Filament colours of other eastern Australian *Caesia* taxa are white (*C. parviflora s. str.*), banded purple and white (*C. chlorantha* F.Muell., *C. parviflora* var. *vittata*), purple (*C. calliantha* in NSW, Victoria and Tasmania), or purple and yellow (white in WA) (*C. setifera s. lat.*). Perianth colour separates *C. walalbai* (white to red-brown) from *C. parviflora* var. *vittata* (blue) and may help distinguish it from *C. parviflora s. str.* and *C. setifera* (white or pale blue). Pedicels are typically longer [(6–)10–20(–30) mm] and more recurved in *C. walalbai* than those of other white-flowered *Caesia* species from Queensland [*C. parviflora s. str.* (*c.* 3–10 mm) and *C. setifera* (*c.* 5–15 mm)], often giving a pendulous appearance to flowers. Inflorescence height tends to be greater in *C. walalbai* (35–75 cm) than in *C. parviflora s. str.* (25–55 cm) or *C. setifera* (< 45 cm). Flower cluster spacing is distant in *C. walalbai* and proximate in *C. parviflora s. str.* The fleshy-fibrous roots of *C. walalbai* distinguish it from *C. setifera*, which has roots with distinct tubers.

Additional specimens examined: QUEENSLAND. Near Beerburrum, 19 Sept. 1959, *S.T. Blake 21001* (BRI, NSW); Blackdown Tableland, *c.* 32 km SE of Blackwater, 18 Apr. 1971, *S.B. Andrews 659 & P. Sharpe* (BRI); Blackdown Tableland, *c.* 1.2 km NW of campsite on Mimosa Creek, *c.* 35 km SE of Blackwater, Sept. 1971, *R.J. Henderson 971, L. Durrington & P. Sharpe* (BRI, NSW); 18 km N of Maroochydore on Noosa Road, 25 Nov. 1972, *P. Sharpe 181* (BRI); Carnarvon Gorge, Nov. 1989, *W. Morley 11* (BRI); Kinkuna National Park, 4 Mar. 1991, *J. Brushe JB535* (BRI*); Neville Lawrie Reserve, Logan City, 14 Dec. 1993, *E.J. Thompson MOR295* (BRI); Gastons Road, west of Bundaberg, 16 Oct. 1996, *A.R. Bean 11024* (BRI); 2 km W of Rules Beach, north-west of Bundaberg, 19 Oct. 1996, *A.R. Bean 11088* (BRI); Burrum Coast National Park, Woodgate section, 22 Oct. 1996, *P.I. Forster 19859 & G. Leiper* (BRI); Mt Moffatt National Park, 29 Dec. 1997, *A.R. Bean 12838* (BRI); Palmgrove National Park, north-west of Taroom, 3 Nov. 1998, *P.I. Forster 23696 & R. Booth* (AD, BRI, MEL, NSW); North Stradbroke Island, track beside swamp off East Coast Road, 25 Oct. 2006, *K.M. Stephens 25100619* (BRI); 4 km N of Mt. Owen, 23 Nov. 2011, *A.R. Bean 31350* (BRI); Carnarvon Station Reserve, Caves Creek Road, SE section of reserve, *c.* 1.6 km from the boundary, 10 Oct. 2014, *B.M. Collins 268 & E.J. Toms* (CANB*); Nour Nour National Park, Hungry Hills, 18 Apr. 2015, *P.I. Forster 42458 & M.B. Thomas* (BRI); Redland Bay, Serpentine Creek Road Historic Cemetery, 24 Sep. 2015, *P.I. Forster 43029, J.J. Beard & G. Leiper* (BRI, MEL); Tin Can Bay, Wide Bay Training Area, 17 Dec. 2015, *P.I. Forster 43677 & M.B. Thomas* (BRI); *c.* 50 km SW of Moura, 20 Mar. 2018, *C. Wiley 32* (BRI).

iNaturalist records: https://inaturalist.ala.org.au/ (verified 22 April 2023): 39647429, 66723760, 94086286, 103129348, 127963076, 128539654, 129380578, 133674933, 133678734, 133678738, 133678744, 133942946, 135761167, 136548593, 137228217, 137724150, 140474507, 140475404, 142430434, 143861124, 144696471, 146263124, 147233053.

Phenology: Flowering occurs primarily between September and December, with additional records in January, March, April, July and August. It is likely dependent on seasonal rains. Flowers open for one day, at mid to late afternoon (T. Johansen pers. comm.).

Distribution: Endemic to Queensland, *Caesia walalbai* is found only in the south-east (Fig. 3). In addition to herbarium vouchers cited above, iNaturalist records confirm the species for Freshwater National Park, Maryborough, Springwood Conservation Park, and Tuan Forest.

Habitat: *Caesia walalbai* is often cryptic in palustrine wetland, coastal and sub-coastal floodplain tree swamp (*Melaleuca* and *Eucalyptus*), and in grassy understorey of open eucalypt woodland, on damp, sandy soils. Its distribution extends inland to the Blackdown Tablelands, Palmgrove National Park, and Carnarvon National Park, where it occurs in eucalypt woodland on sand atop sandstone ridges.

Conservation status: *Caesia walalbai* is relatively common, but often cryptic, at known localities across its distribution and is not considered threatened.

Etymology: 'Walalbai' originates from Butchulla/Badjala, the language of the Butchulla/Badjala people, from whose country the holotype was collected. It means small or little, in reference to the relative size of the flowers. The name was provided by Darren Blake, Traditional Owner of Butchulla/Badjala country and permission was granted for the application of the name for this species.

Common name: Drooping Grass-lily.

Notes: As is common for most eastern-Australian *Caesia* taxa (*C. alpina, C. parviflora, C. setifera*), *C. walalbai* is easily overlooked in its habitat unless it is flowering. Consequently, the genus is represented by a relatively small number of specimens in Australian herbaria. Additionally, the characters required for identification of *Caesia* taxa (e.g., flowers, seeds, roots) are often not collected or do not retain necessary details (e.g., colour) in herbarium specimens. This results in difficulty providing accurate specimen determinations and may have contributed to the oversight of *C. walalbai* in south-east Queensland. Superficially, *C. walalbai* is very similar

to *C. parviflora s. str.* and *C. setifera* and specimens have historically been determined as *C. parviflora* or *C. parviflora* var. *parviflora*.

The distribution of *Caesia setifera* in Queensland is likely confined to the far north (Cape York Peninsula), while the furthest north *C. parviflora* var. *parviflora* (*C. parviflora s. str.*) has been confirmed is Noosa. Therefore, the distribution of *C. walalbai* only intersects with *C. parviflora* var. *parviflora* and *C. parviflora* var. *vittata*, between Noosa and Brisbane (Fig. 3). Records at BRI of *Caesia parviflora* var. *parviflora* from Mackay (BRI AQ0053413) and near Emerald (BRI AQ0739761) are likely to represent collections of *Caesia walalbai*, but have not been examined.

Caesia walalbai is a new species separated from the concept of *C. parviflora s. lat.* in eastern Australia. Formal recognition of this taxon and defining its distribution will aid in delimitation of other taxa within the *C. parviflora* complex and their associated distributions, which have historically been poorly defined (Henderson 1987). A study of the *Caesia parviflora* complex is ongoing, but a description of the typical form occurring in the Sydney region (currently var. *parviflora*) is provided below for comparison to *C. walalbai*.

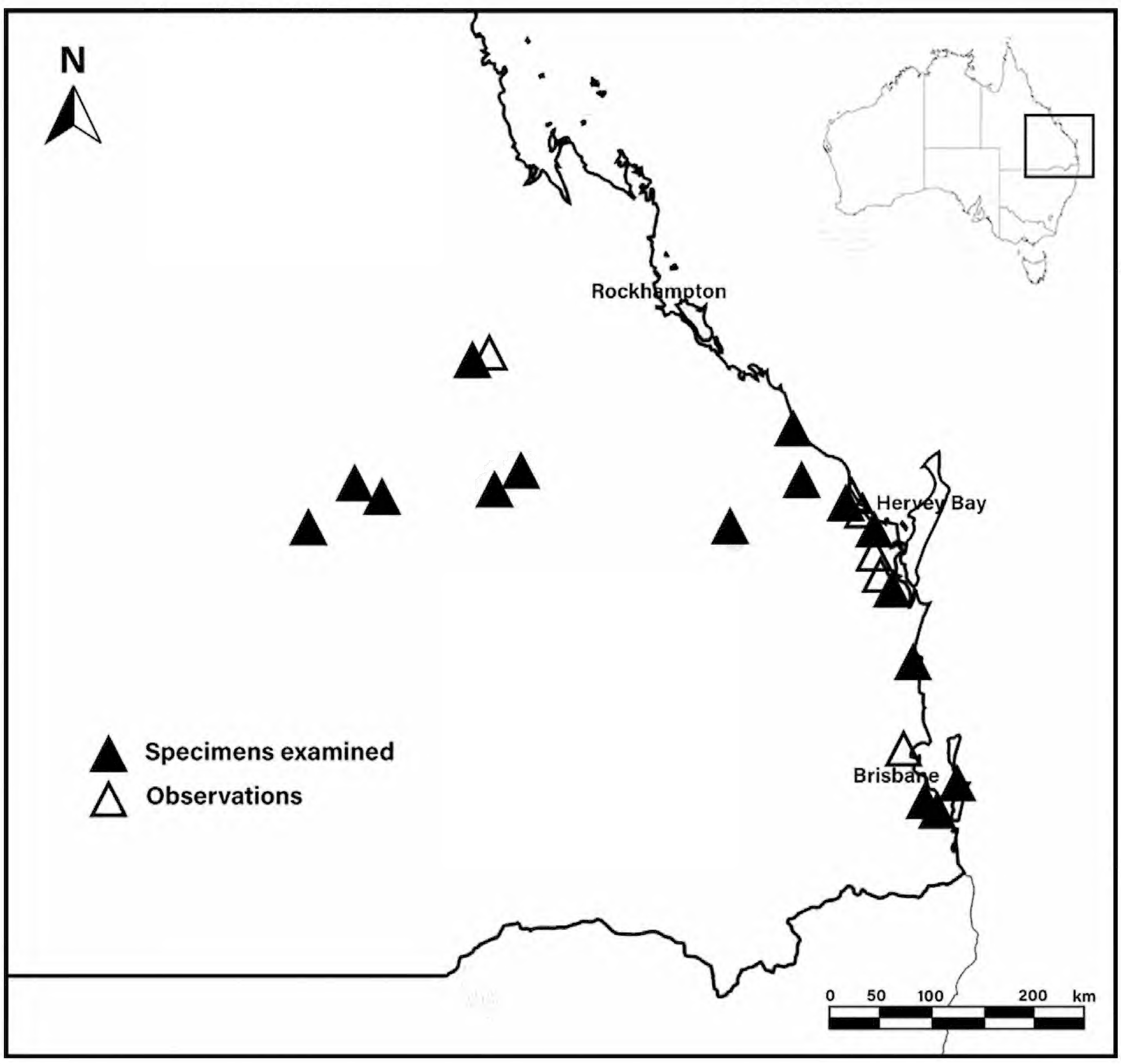

Figure 3. Distribution of *Caesia walalbai* in south-east Queensland, Australia. Solid black triangles (▲) denote specimens examined from BRI, open triangles (△) denote confirmed observations from iNaturalist.

Caesia parviflora R.Br., *Prodromus florae Novae Hollandiae et insulae Van-Diemen* 277 (1810).

Type citation: "(J.D.) v.v."

Lectotype: New South Wales: [in apricis sterilibus prope Sydney, 16 October 1803], *R. Brown s.n.* [Iter Austral. 5693] (lecto: BM 000990656*; isolecto: BM 000990659*, CANB 279204*, K 000794739*, K 000794740*, MEL 107238*, NSW 154908, P 00852457*), designated by Henderson (1987: 471).

Syntypes: New South Wales: Port Jackson, *R. Brown s.n.* (syn: BM 000990657*, BM 000990658*).

Caesia dichotomizans Gand., *Bulletin de la Société Botanique de France* 66: 292 (1919).

Type citation: "Australia, Victoria (Walter!)."

Lectotype: Victoria: 1902, *Walter s.n.* (lecto: NSW 120960 ex Herb. Walter), designated by McGillivray (1973: 333; as 'holotype').

Syntype: Victoria: Dividing Ranges, Nov. 1898, *Walter* (syn: NSW).

Rhizomatous, annual *herb* to 55 cm high; *roots* fleshy, narrowly tuberous. *Leaves* 12–31 cm long, linear, ascending to recurved, basal, seasonally senescent, green, abaxial and adaxial surfaces discolorous when fresh, almost glaucous above, ± concolorous when dry, apices acute; lamina 1.1–1.9(–3.2) mm wide, slightly biconvex when young, shallowly canaliculate at maturity, finely ribbed, glabrous, margins plain and appearing finely sinuate due to many small projections; sheath papery, white to pale brown or red, persists as fine bristles following senescence. *Inflorescences* 1-per-plant (but plants commonly clustered, so appearing multiple), 25–55 cm tall, paniculate; axis ± terete when fresh, drying angular, slender, 1–several-branched; flower clusters usually proximate, commonly overlapping or almost so, (2–)3–4-flowered. Bract subtending lowest branch linear, variable in length, 5–14 mm long, 3–7× length of upper bracts subtending flower clusters; upper bracts ovate, 1.3–2.4 mm long, white to dark grey or with a purplish tint. *Pedicels* 2.6–6.0(–10) mm long, slender, erect to gently curved, green or brownish. *Flowers* pedicellate, erect to spreading. *Perianth* segments 6, 2.7–3.9 mm long, narrowly elliptic or oblong, thin, spreading to recurved, two-toned in colour. Outer whorl white (or pale pink with age) to grey-brown with subterminal, short, reflexed, apical trichomes, inner whorl white to cream, both whorls with green to grey-brown nerves and obtuse apices, segments twist strongly following anthesis and commonly age purple. *Stamens* 6, equal, 1.9–2.8 mm long, epitepalous, attached slightly above tepal base; anthers *c.* 0.6 mm long, yellow, dorsifixed, versatile; filaments fusiform, white with clear apex. *Ovary* green, ± spheroidal, irregularly tuberculate, 3-locular; ovules 2 per locule; placentation axile; style simple, filiform, of similar length to stamens; stigma minutely capitate. *Capsules* 3.1–4.7 mm wide, 2.6–3.8 mm long, tripartite, loculicidual, 1 or 2 seeds developing per locule, green. *Seeds* subglobular, with a ventral groove where the aril is attached, 1.8–2 mm wide; testa dull black, granular with sparse, irregular, pillar-form tubercles; aril papery, not sheathing seed. (Fig. 4)

Diagnostic characters: Differs from *Caesia parviflora* var. *vittata* by its short habit, to 55 cm tall; narrow leaves 1.1–1.9(–3.2) mm wide, margins with many small projections; primarily white flowers, with short perianth segments 2.7–3.9 mm long, irregularly tuberculate ovary, anther filaments all white, and style of similar length to the stamens.

Selected specimens examined: New South Wales: Elanora Heights, 50 m, 8 Nov. 1970, *A. Rodd 1522* (NSW); Royal National Park, Waterfall, 105 m, 4 Dec. 1970, *R. Coveny 3415 & M.H. Zenk* (NSW); Carrington Falls road, 1 km from the falls, 565 m, 29 Oct. 1973, *A. Rodd 2424* (NSW); 21 km S of Woodburn on road through Bundjalung National Park, 5 m, 10 Nov 1983, *R.J. Henderson H3046, G.P. Guymer & P.R. Sharpe* (BRI, NSW); corner of Illaroo and Bundanon Roads, 14.9 km W of junction at Shoalhaven River Bridge, Nowra, 200 m, 3 Jan. 1997, *P.C. Jobson 4546* (NSW); Tomago Sand Beds, Tanimbla Station, 30 Oct. 2001, *D.L. McNair 914* (NSW); corner of Litton Street and Greenhaven Drive, Emu Heights, 20 Dec. 2008, *K.A. McColl s.n.* (NSW 792509); Lake Parramatta, *c.* 300 m along walking track on SE side of lake from carpark, 23 Nov. 2021, *R.L. Barrett & S.A. Rowntree RLB 9372* (BRI, MEL, NE, NSW); Jellybean Pool lower carpark, Glenbrook, Blue Mountains National Park, 25 Dec. 2021, *R.L. Barrett, Z.E. Davies, X.V. Davies & F.F. Barrett RLB 9375* (CANB, MEL, NSW).

Selected iNaturalist records: https://inaturalist.ala.org.au/ (verified 22 April 2023): 137385417; 140631154, 141589916, 141747755, 143351547, 143476463, 145040917, 143476463, 145040917, 145317407, 146954976, 147000106, 149702075.

Phenology: Flowering occurs primarily between September to January with occasional records at other times of the year.

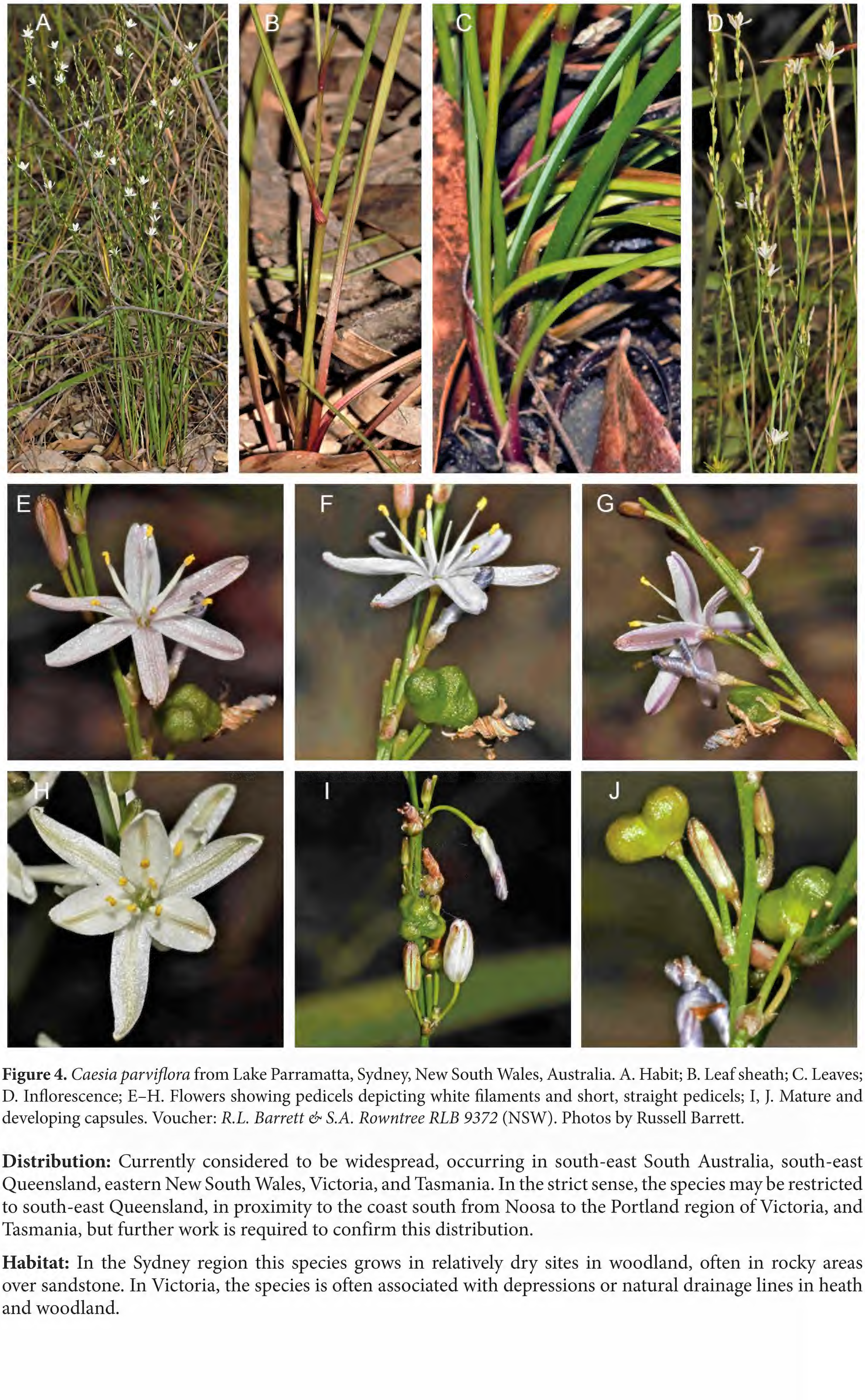

Figure 4. *Caesia parviflora* from Lake Parramatta, Sydney, New South Wales, Australia. A. Habit; B. Leaf sheath; C. Leaves; D. Inflorescence; E–H. Flowers showing pedicels depicting white filaments and short, straight pedicels; I, J. Mature and developing capsules. Voucher: *R.L. Barrett & S.A. Rowntree RLB 9372* (NSW). Photos by Russell Barrett.

Distribution: Currently considered to be widespread, occurring in south-east South Australia, south-east Queensland, eastern New South Wales, Victoria, and Tasmania. In the strict sense, the species may be restricted to south-east Queensland, in proximity to the coast south from Noosa to the Portland region of Victoria, and Tasmania, but further work is required to confirm this distribution.

Habitat: In the Sydney region this species grows in relatively dry sites in woodland, often in rocky areas over sandstone. In Victoria, the species is often associated with depressions or natural drainage lines in heath and woodland.

Conservation status: *Caesia parviflora* is relatively common across a broad distribution and is not considered threatened.

Etymology: From the Latin *parvi-* (small) and *florus* (flower).

Common name: Pale Grass-lily.

Notes: Typification of *Caesia parviflora* follows Mabberley & Moore (2022).

Henderson (1987: 419) noted that *Bidwillia glaucescens* Herb. (type of the genus *Bidwillia* Herb.) may be a synonym of *Caesia parviflora*. However, examination of the protologue reveals that *B. glaucescens* was described as having staminal filaments that are dilated at the base and pubescent, so it is more likely to represent a species of *Arthropodium* R.Br., but application of the name remains uncertain.

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Zieria nubicola (Rutaceae), a new and highly restricted species from New South Wales, Australia

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Abstract

Zieria nubicola H.K.Orel & Duretto *sp. nov.* (Rutaceae), a highly restricted species from Cambewarra Mountain on the south-central coast of New South Wales, is formally described and illustrated. Notes on the species distribution, habitat and conservation status are also provided.

Introduction

Zieria Sm. (Rutaceae) is a genus containing 63 Australian species found from north-eastern Queensland to Tasmania and South Australia, and one New Caledonian species, *Z. chevalieri* Virot, which is found on Mt Kaala, Grande Terre. The genus contains many narrow endemics and though it has been revised recently (Armstrong 2002; Duretto and Forster 2007, 2008; George *et al.* 2013) additional species new to science are still being identified (Duretto 2019; Forster 2020). *Zieria tuberculata* J.A.Armstr. is endemic to the South Coast of New South Wales and known from two widely separated areas, the Mount Gulaga (Mount Dromedary) district between Tilba Tilba and Central Tilba, and the Cambewarra Range, c. 9.5 kilometres north of Nowra, Central Coast. The Mount Gulaga area is where the majority of collections of this species have been made, including the type collection. *Zieria tuberculata* is listed as a Vulnerable Species in the *New South Wales Biodiversity Conservation Act* (BCA 2016).

In footnotes in his seminal taxonomic treatment of the genus *Zieria*, Armstrong (2002, pp. 277, 278, 368) made reference to an undescribed species known from a single specimen that was labelled *Zieria granulata* C.Moore ex Benth., and collected at Good Dog Mountain, Cambewarra Range in 1931 (F.A. Rodway [Rodway Herbarium No. 993, NSW 19738]; notes with specimen indicate there is a possible duplicate, labelled *Rodway 597*, at Kew Gardens Herbarium (*n.v.*)). Prior to publishing his monograph, Armstrong and JDB searched for this species but were unable to find it. Several years later, JDB located the population and, being aware of its nonconformity to any existing species, collected four cuttings from different plants along with a voucher specimen. This voucher (Briggs, J.D. 2858a, 2000/09/20, CANB 627223.1), along with the Rodway collection and two additional collections of the same taxonomic entity (Tindall & Keith *s.n.*, 2002/09/18, WOLL 8031; Tindall & Keith *s.n.*, 2002/09/18, WOLL 8146), have since been treated as *Z. tuberculata* (e.g., George *et al.* 2013)

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and entirely represent the disjunct population of *Z. tuberculata* from the Cambewarra Range. The cuttings made by JDB were subsequently grown at the Australian National Botanic Gardens (ANBG), Canberra, where they have been referred to as *Zieria* aff. *tuberculata*.

In the course of genetic studies on a group of closely related *Zieria* species, including material from *Z. tuberculata*, *Z. granulata* and *Z.* aff. *tuberculata* growing at the ANBG, it became apparent that *Z.* aff. *tuberculata* is a discrete taxon, sister to *Z. granulata*, that is worthy of recognition at the rank of species (Orel *et al.* 2023). However, Orel *et al.* (2023) did not evaluate the morphology of *Z.* aff. *tuberculata* and so did not formally describe the species. Subsequent field surveys and collections made by HKO and MFD from five plants have provided the morphological support necessary to recognise the new species, *Z. nubicola* H.K.Orel & Duretto, which is described herein.

Materials and methods

Collections of closely related species (informed by Orel *et al.* 2023) housed at the National Herbarium of New South Wales, along with new field collections of *Zieria nubicola* were examined, as were the descriptions of *Z. granulata* and *Z. tuberculata* published and illustrated by Armstrong (2002). Type material of *Z. granulata* and *Z. tuberculata* at Kew Gardens Herbarium was observed via their online website (accessed 23 January 2023: http://apps.kew.org/herbcat/gotoHomePage.do). Measurements of features made during these examinations provide the basis for our description of this species. Material was collected under NSW DPIE permits SL100569 (issued to the Botanic Gardens Trust, Botanic Gardens of Sydney) and SL102586 (issued to Harvey Orel).

Taxonomic treatment

Zieria nubicola H.K.Orel & Duretto, sp. nov.

Type [precise locality details withheld]: Australia, New South Wales: Cambewarra Range Nature Reserve, 34°48'S 150°34'E, 22 Sept. 2022, *H.K. Orel HKO79 & M.F. Duretto* (holotype: MELUD131643a; isotypes: BRI, CANB, MEL, NSW).

Tall shrub or small tree up to 3.5 m high. *Branchlets* sparsely to moderately-densely glandular-tuberculate, with a dense indumentum of white stellate hairs, hairs covering tubercles, without decurrent leaf-bases; older branches with less prominent tubercles, indumentum present but not as dense. *Leaves*: petiole 5–12 mm long, densely stellate-hairy, sparsely to moderately-dense glandular tuberculate, hairs covering tubercles; lamina trifoliolate, leaflets similar though central leaflet longer; central leaflet linear to broadly linear, 23–53 mm long, 3–6 mm wide; upper surface deep green, glabrescent or having a sparse indumentum of stellate hairs, with scattered raised glandular tubercles, midvein sunken; lower surface whitish, with a dense velvety indumentum of stellate hairs, densely glandular tuberculate, tubercles also scattered along raised midvein, lateral veins also slightly raised; apex rounded and blunt; margin entire, not appearing dentate, slightly recurved (becoming revolute on drying). *Inflorescence* a dichasial cyme, axillary, shorter than the leaves, (5–)15–50 flowers per inflorescence; peduncle 2–20 mm long, secondary branches 1–11 mm long, slightly glandular tuberculate, with a dense stellate indumentum; bracts 1 or 2 at each node of inflorescence, 0.5–5.0 mm long, persistent or deciduous; pedicels 1.0–3.1 mm long, densely stellate hairy, usually with glandular tubercles. *Flowers* 5.5–7 mm diameter at anthesis. *Sepals* 1.0–1.5 mm long, c. 1 mm wide, ovate to triangular shape; abaxial surface with a dense indumentum of stellate hairs and ± tuberculate; adaxial surface smooth and hirsute with simple hairs. *Petals* white to light/faded pink, valvate in bud, 4.0–4.5 mm long, 1.5–2.0 mm wide; stellate-pubescent on both surfaces; apex inflexed. *Disc* 4-lobed, glabrous. *Stamens* 4; filaments *c.* 1.2 mm long, glabrescent to sparsely hairy abaxially (on the outer side), glabrous adaxially, smooth or with minute tubercles just before the apex, not strongly dilated towards the base; anthers *c.* 0.6 mm long, not apiculate. *Gynoecium* glabrous; style *c.* 0.7 mm long. *Cocci* (immature only seen, *Rodway 993*, NSW 19738) not obviously tuberculate. (Figs 1–3)

Diagnostic characters: *Zieria nubicola* differs from *Z. granulata* in having branches with a dense stellate indumentum that also covers the glandular tubercles (versus pubescent on young branches only, and glandular tubercles glabrous), broader leaflets (3–6 mm wide) with only slightly recurved margins (on fresh material; versus 0.5–2.5 mm wide, margins revolute), larger flowers, in particular, longer sepals (1.0–1.5 mm long, versus 0.5–0.8 mm long) and longer petals (4.0–4.5 mm long, versus 1.7–2.5 mm long); and from *Z. tuberculata* in having petals that are valvate in bud (versus imbricate), sepals that are ovate (verses narrowly triangular and tapering), shorter bracts/bracteoles on the inflorescence (to 5 mm long, versus to 13.3 mm long), and filaments which are not strongly dilated at the base and have hairs on the abaxial surface (versus dilated at base

and glabrous). *Zieria nubicola* differs from both *Z. granulata* and *Z. tuberculata* in possessing fewer-flowered inflorescences (5–50 flowers per inflorescence versus 50–180 flowers).

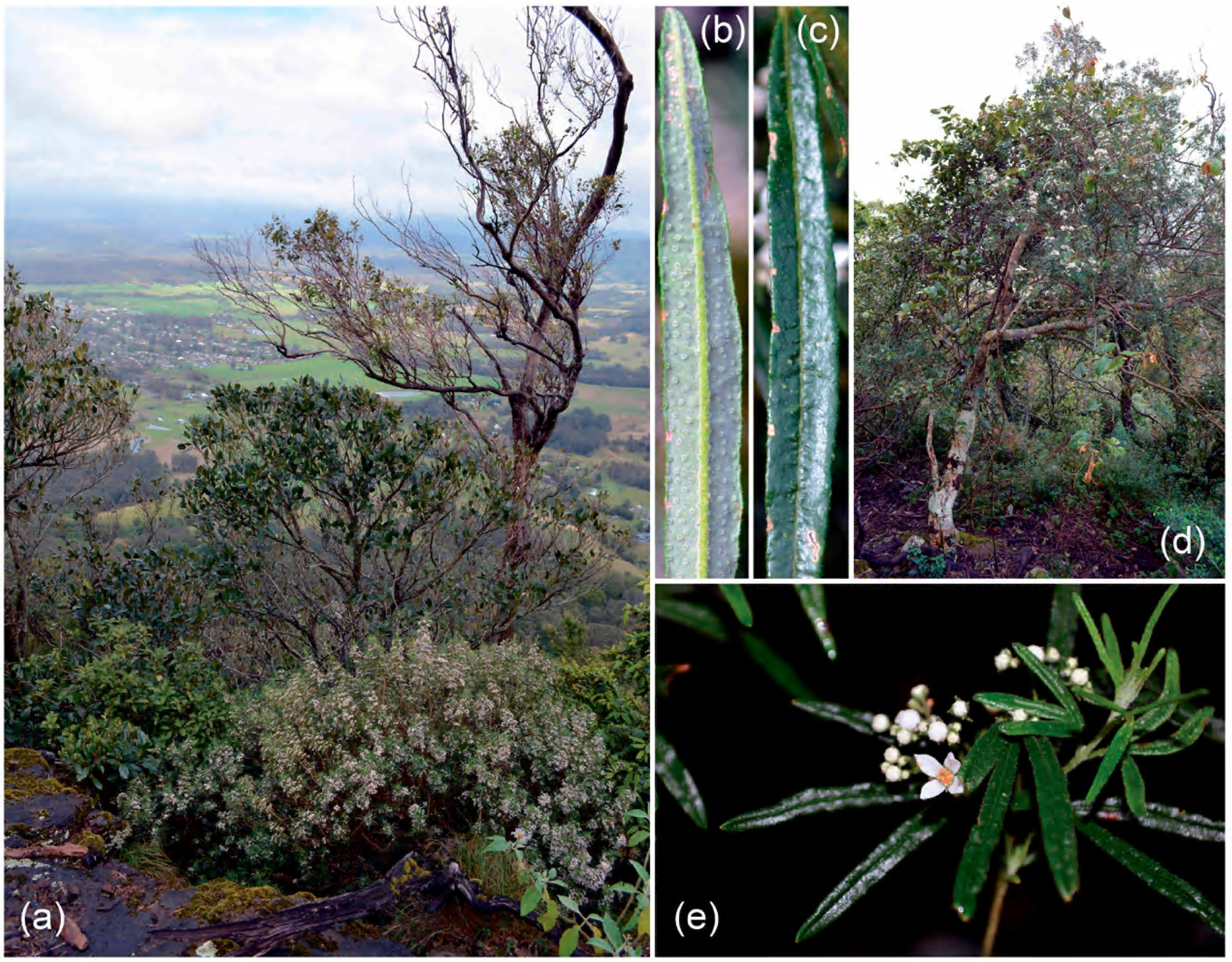

Fig. 1. *Zieria nubicola*. (a) Habitat; (b) abaxial surface of leaf; (c) adaxial surface of leaf; (d) whole plant (c. 3.5 m tall); (e) detail of inflorescence. Photographs by H. Orel.

Phenology: Flowers recorded from September–November. Fruit recorded from November.

Etymology: The specific epithet combines the Latin word *nubes* ('cloud') with the suffix *-cola* ('dweller', 'inhabitor'), in reference to the mist and clouds that frequently shroud the mountain on which the species occurs.

Distribution and ecology: *Zieria nubicola* is apparently confined to Good Dog Mountain, Cambewarra Range, north of Nowra, New South Wales. This mountain is also referred to as Cambewarra Mountain (see Loughnan and Ward 1971; Carr 1983; Wright 2013), and this name appears to be more commonly used contemporarily. The species is localised to an exposed ridge of igneous rocks among tall heath/scrub, where it is common and dominant in the small area that it occurs. Individual plants probably number > 300, though an accurate number was difficult to assess by the authors on a single excursion to the site due to the terrain.

Conservation Status: The species is apparently very localised and known with certainty from a single population where it is common though restricted to a particular plant community. Surveys of similar habitat are required to ascertain if there are additional populations. A limited search of other areas near Cambewarra Lookout did not locate additional plants or suitable habitat of exposed rock. The population appears secure in the Cambewarra Lookout section of the Cambewarra Range Nature Reserve. When visiting the population in September 2022 no obvious threats to the species were apparent, except for some minor disturbance to the site caused by people walking through the population. Some recruitment was observed though most plants were large and probably quite old. Any development of the site or increased visitation could be catastrophic to the known population.

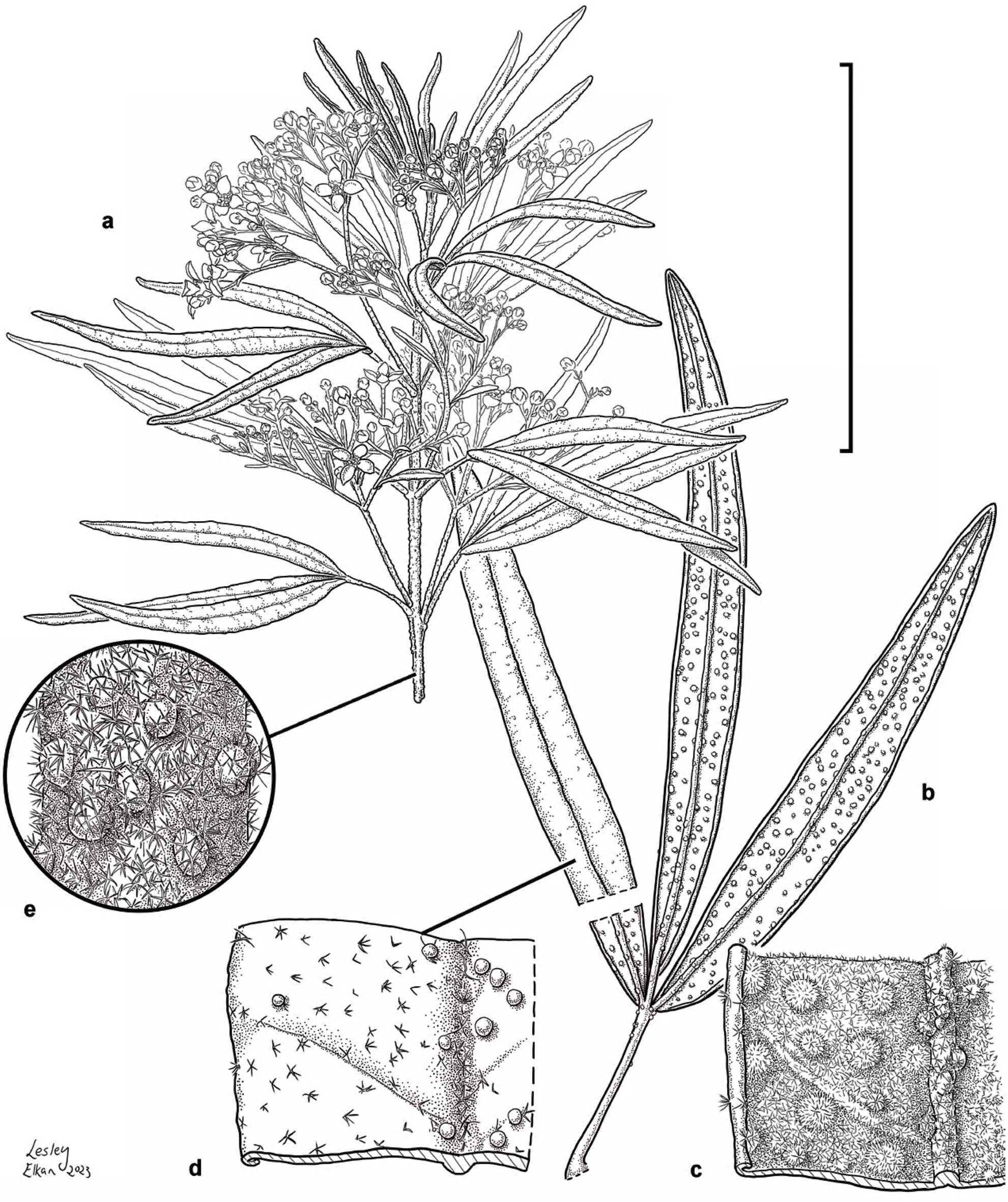

Fig. 2. *Zieria nubicola*. (a) flowering habit; (b) leaf, showing abaxial and adaxial surfaces; (c) abaxial leaf surface detail; (d) adaxial leaf surface detail; (e) stem detail. Scale bar: (a) = 60 mm; (b) = 30 mm; (c) & (d) = 5 mm; (e) = 2.5 mm. Voucher: *Orel 77 & Duretto* (NSW). Illustrations by L. Elkan.

The species appears to be eligible to be listed as a Vulnerable Species under the *New South Wales Biodiversity Conservation Act* (BCA 2016; see also IUCN 2012, 2022) following the criteria as set out in the *New South Wales Biodiversity Conservation Regulation* (BCR 2017) under Clause 4.7 (Very highly restricted geographic distribution of species–vulnerable species; IUCN criterion D2). The species satisfies this criterion as it is known for certain from one population with an area of occupancy (AOO) and an extent of occurrence (EOO) that are both less than 10 km^2. The species does not appear to be eligible, using the limited information at hand, to be listed under Clauses 4.2 (Reduction in population size of species) and 4.4 (Low numbers of mature individuals of species and other conditions) as there is no evidence of population decline, Clause 4.3 (Restricted geographic distribution of species and other conditions) as there is no evidence of population decline or, reduction or extreme fluctuations in geographic distribution or reduction or extreme fluctuations

in habitat extent and quality, Clause 4.5 (Low total numbers of mature individuals of species) as the number of mature individuals is unknown as a thorough survey has not been completed though there may be only a few hundred individuals, or Clause 4.6 (Quantitative analysis of extinction probability) as no immediate threatening processes affecting the known population were identified by the authors.

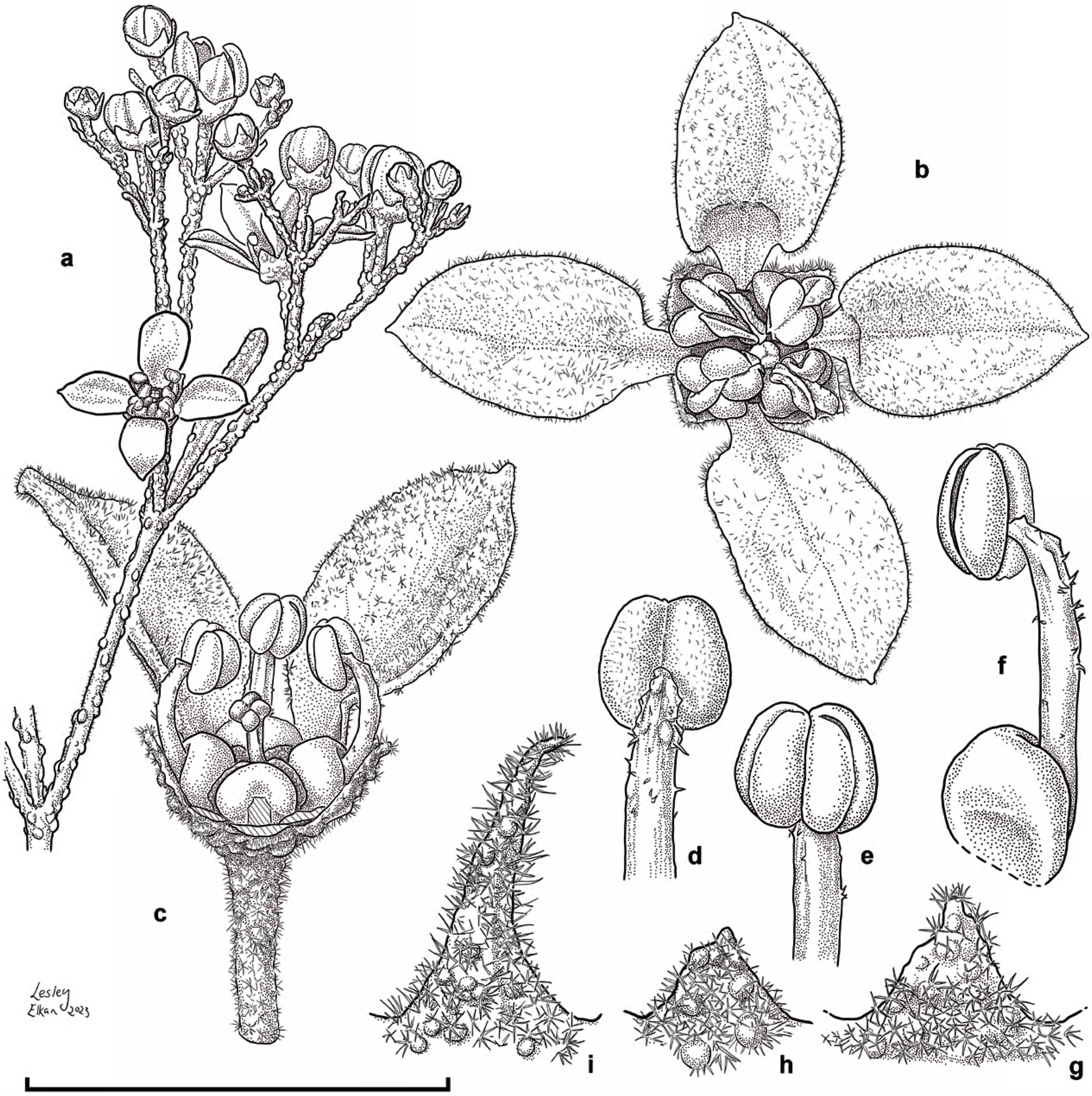

Fig. 3. *Zieria nubicola* (a–g): (a) inflorescence detail; (b) flower, top view; (c) flower, side view, two petals and one sepal removed; (d) stamen with anther, abaxial view; (e) stamen with anther, adaxial view; (f) stamen with anther, side view; (g) sepal, abaxial view. *Zieria granulata*: (h) sepal, abaxial view. *Zieria tuberculata*: (i) sepal, abaxial view. Scale bar: (a) = 15 mm; (b) & (c) = 5 mm; (d–i) = 2.5 mm. Vouchers: (a–g) *Orel 77 & Duretto* (NSW); (h) *J.J. Fletcher s.n.* (NSW2850); (i) *J.D. Briggs 2444* (NSW931867). Illustrations by L. Elkan.

The species appears to be secure as it is found on an isolated ridge that is found within a state Nature Reserve and is surrounded by forest; the site does not seem to be visited regularly. The woody weed, *Lantana camara*, was observed in areas near the species and is common locally; this will be a future threat if it becomes established within the population and overshadows plants and restricts recruitment. Climate change is considered a threatening process as the area where the species is found is wet and often shrouded in clouds. Any change in the local microclimate that could potentially make the area dryer and increase the frequency of fires may pose a threat to the species. If the site became more accessible, visitor numbers increased, the surrounding vegetation was disturbed or cleared, or the population number declined then the species would likely satisfy

the requirements to be listed as Critically Endangered under the *New South Wales Biodiversity Conservation Act* (2016).

Additional specimens examined [precise details withheld]: NEW SOUTH WALES: Central Coast: Good Dog Mountain, Cambewarra Range, *F.A. Rodway [Rodway Herbarium No. 993]*, 8 Nov. 1931 (NSW 19738) Cambewarra Range Nature Reserve, 34°48'S 150°34'E, 22 Sept. 2022, *H.K. Orel HKO 76 & M.F. Duretto* (MELUD131640a, NSW); *ibid*, *H.K. Orel HKO 77 & M.F. Duretto* (MELUD131641a, NSW); *ibid*, *H.K. Orel HKO 78 & M.F. Duretto* (MELUD131642a, NSW); *ibid*, *H.K. Orel HKO 80 & M.F. Duretto* (MELUD131644a).

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